STATE OF KUWAIT

MINISTRY OF PUBLIC WORKS
ROADS ADMINISTRATION

GENERAL SPECIFICATIONS
FOR
KUWAIT ROADS AND HIGHWAYS

JANUARY 2012

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TABLE OF CONTENTS

SECTION 1: GENERAL 1-1

100 - GENERAL 1-1
101 - GENERAL OBLIGATIONS AND RESPONSIBILITIES 1-2
102 - SPECIAL CONDITIONS FOR SAFETY REGULATIONS FOR INDIVIDUALS, PROPERTIES AND UTILITIES 1-3
103 - ENGINEER'S SITE OFFICE FACILITIES 1-8
104 - MONTHLY PROGRESS PHOTOGRAPHS 1-9
105 - SIGN BOARDS 1-10
106 - TEMPORARY WORKS 1-10
107 - ENGINEER'S TRANSPORT 1-11
108 - SITE ACCESS 1-11
109 - PROTECTION OF THE WORKS 1-11
110 - PROJECT MEETING 1-12

SECTION 2: EARTHWORKS 2-1

200 - GENERAL 2-1
201 - MATERIALS UTILISED IN EARTHWORK CONSTRUCTION 2-2
202 - MAIN MACHINERY UTILISED IN EARTHWORK CONSTRUCTION 2-4
203 - METHOD OF EXECUTION OF WORKS 2-6
204 - TESTING REQUIREMENTS 2-17
205 - MEASUREMENT AND PAYMENT FOR ROADWAY EXCAVATION AND FILLING WORKS .. 2-20
206 - SUBGRADE CONSTRUCTION 2-23
207 - REMOVAL OF EXISTING PAVEMENT AND OBSTRUCTIONS 2-25
208 - STRUCTURE EXCAVATION AND BACKFILLING 2-36
209 - PERVIOUS BACKFILL 2-45
210 - GEOTEXTILE 2-46
211 - GEOGRID 2-48

SECTION 3: SUB-BASE AND BASE COURSES 3-1

300 - GENERAL 3-1
301 - CONTROL OF MATERIALS FOR SUB-BASE AND BASE COURSES 3-2
302 - MAJOR EQUIPMENT USED FOR SUB-BASE AND BASE COURSES 3-4
303 - AGGREGATE SUB-BASE AND BASE COURSES 3-5
304 - SAND ASPHALT SUB-BASE AND BASE COURSES 3-11
305 - CEMENT STABILIZED BASE COURSE 3-15
306 - RECYCLED AGGREGATE SUB-BASE COURSE 3-21

SECTION 4: ASPHALT WORKS 4-1

400 - GENERAL 4-1
401 - CONTROL OF MATERIALS FOR ASPHALT 4-3
402 - MATERIAL REQUIREMENTS FOR ASPHALT WORKS 4-5
403 - MAJOR EQUIPMENT USED FOR ASPHALT WORKS 4-12
404 - ASPHALTIC CONCRETE 4-20
405 - PRIME COAT 4-33
406 - TACK COAT 4-35
407 - PAVEMENT REPAIRS 4-37
408 - SEAL COATS 4-43
409 - PLANT MIX SEAL 4-48
410 - SLURRY SEAL 4-51
411 - CEMENT MODIFIED ASPHALT COURSES 4-54
412 - RUMBLE STRIPS 4-58
413 - SHOULDER TREATMENT 4-58

414 - RECYCLED ASPHALT PAVEMENT 4-59
415 - SURFACE RIDEABILITY MEASUREMENT 4-67

SECTION 5: CONCRETE WORKS 5-1

500 - GENERAL 5-1
501 - MATERIALS AND TESTING 5-1
502 - CLASSES OF CONCRETE 5-7
503 - MIX DESIGN 5-9
504 - METHOD OF CONSTRUCTION FOR REINFORCED CONCRETE 5-9
505 - PRECAST CONCRETE 5-34
506 - INTERLOCKING PAVING BLOCKS 5-38
507 - CONCRETE TESTING 5-41
508 - SUPERSTRUCTURE CONSTRUCTION 5-42
509 - APPROACH SLABS 5-49
510 - GROUT PADS 5-49
511 - WATERSTOPS 5-50
512 - NOT USED 5-51
513 - ACCESS DOORS 5-51
514 - STRUCTURAL STEEL 5-51
515 - MISCELLANEOUS CONCRETE STRUCTURES 5-51
516 - PROTECTIVE MEMBRANES 5-53
517 - PROTECTIVE PAINTING OF CONCRETE 5-56

SECTION 6: STORMWATER DRAINAGE 6-1

600 - SUPPLY OF PIPES 6-1
601 - HIGH DENSITY POLYETHYLENE (HDPE) PIPES AND FITTINGS 6-5
602 - CONCRETE PIPES 6-12
603 - TESTING OF CONCRETE PIPES AT PLACE OF MANUFACTURE 6-14
604 - DUCTILE AND CAST IRON AND STEELWORK 6-14
605 - EARTHWORKS 6-17
606 - PIPE LAYING AND CONNECTIONS 6-21
607 - JOINTS 6-23
608 - TESTING INSTALLED PIPELINES 6-23
609 - CONCRETE WORKS FOR PIPE-LAYING AND DITCHES 6-26
610 - CONCRETE WORK FOR MANHOLES, INLETS, CONCRETE TRENCH IN CARRIAGEWAY, AND PIPE HEADWALLS AND OUTLETS 6-27
611 - MODIFICATION OF EXISTING MANHOLES 6-28
612 - BOX CULVERTS AND CONDUITS 6-29
613 - PROTECTION OF STRUCTURES 6-37
614 - PIPELINE CONSTRUCTION BY NON-DISRUPTIVE METHODS (MICROTUNNELLING) 6-39

SECTION 7: TRAFFIC MARKINGS & SIGNS 7-1

700 - GENERAL 7-1
701 - THERMOPLASTIC PAVEMENT MARKING AND TRAFFIC PAINT 7-2
702 - GLASS BEADS 7-12
703 - PAVEMENT MARKERS 7-14
704 - TRAFFIC SIGNS 7-20

SECTION 8: MATERIALS FOR WATER WORKS 8-1

800 - GENERAL 8-1
801 - MATERIALS 8-4
802 - RESPONSIBILITY FOR MATERIALS 8-5
803 - PIPES, VALVES AND FITTINGS 8-6

804 - FLANGES – DIMENSION REQUIREMENTS 8-21
805 - FACE TO FACE DIMENSIONS FOR VALVES 8-22
806 - SUBMITTAL SCHEDULES 8-23

SECTION 9: WATER PIPELINE CONSTRUCTION 9-1

900 - GENERAL 9-1
901 - EXCAVATION & PREPARATION OF TRENCHES 9-4
902 - PIPEWORK, VALVES AND FITTINGS 9-10
903 - VALVE AND HYDRANT CHAMBERS 9-16
904 - ANCHORAGES 9-17
905 - HYDROSTATIC TESTING 9-18
906 - BACKFILLING 9-20
907 - DISINFECTING & FLUSHING OF FRESH WATER LINES 9-22
908 - CONNECTIONS TO EXISTING MAINS 9-24
909 - REMOVAL AND RECOVERY OR DISPOSAL OF EXISTING MAINS, VALVES AND FITTINGS 9-25
910 - TREATMENT OF ABANDONED PIPELINES 9-27
911 - CONTROL CABLES 9-28
912 - SUBMITTAL SCHEDULE 9-44

SECTION 10: SITE LABORATORIES 10-1

1000 - SITE LABORATORIES 10-1
1001 - “TYPE A” SOILS AND CONCRETE LABORATORY 10-13
1002 - “TYPE B” ASPHALT LABORATORY 10-18
1003 - “TYPE C” ASPHALT, SOILS AND CONCRETE LABORATORY 10-22

SECTION 11: PRESTRESSED CONCRETE WORKS 11-1

1100 - GENERAL 11-1
1101 - MATERIALS 11-4
1102 - POST-TENSIONED CONCRETE CONSTRUCTION 11-5
1103 - PRE-TENSIONED CONCRETE CONSTRUCTION 11-13
1104 - MEASUREMENT AND PAYMENT 11-15

SECTION 12: METAL WORKS 12-1

1200 - GENERAL 12-1
1201 - MATERIALS AND TESTING 12-1
1202 - STRUCTURAL STEEL FABRICATION 12-6
1203 - FENCING 12-26
1204 - METAL BEAM GUARD RAIL 12-30
1205 - RAILING 12-34
1206 - ENERGY ABSORBING TERMINAL (E.A.T.) SYSTEMS 12-36

SECTION 13: BEARINGS, EXPANSION AND FIXED JOINTS..... 13-1

1300 - GENERAL 13-1
1301 - ELASTOMERIC BEARINGS 13-2
1302 - POT BEARINGS 13-3
1303 - FABRIC BEARING PADS..... 13-6
1304 - ELASTOMERIC EXPANSION JOINTS 13-6
1305 - PREFORMED EXPANSION JOINT SEALS 13-9
1306 - ASPHALTIC PLUG EXPANSION JOINTS 13-10

SECTION 14: LIGHTING AND ELECTRICAL WORKS 14-1

1400 - GENERAL 14-1
1401 - REQUIREMENTS FOR LIGHTING AND ELECTRICAL WORKS 14-2
1402 - TRENCH , BACKFILL AND INSTALLATION OF CABLE & ROAD CROSSING DUCTS 14-20
1403 - FOUNDATIONS FOR LIGHTING - MASTS AND COLUMNS 14-25
1404 - ELECTRIC CABLES 14-27
1405 - EARTH BONDING AND GROUNDING 14-32
1406 - CABLE TRAYS, TRUNKING AND CONDUIT 14-33
1407 - LIGHTING MASTS 14-35
1408 - LIGHTING COLUMNS, 16 m AND 22 m HIGH 14-38
1409 - LIGHTING- COLUMNS, 6m, 8m, 10m AND 12 m HIGH 14-42
1410 - LUMINAIRES FOR 25 m TO 40 m MOUNTING HEIGHT 14-44
1411 - LUMINAIRES FOR 6 M TO 22 M MOUNTING HEIGH 14-46
1412 - PERFORMANCE REQUIREMENTS FOR LIGHTING SYSTEMS 14-54
1413 - LIGHTING SYSTEM FOR UNDERCROSSINGS 14-54
1414 - LIGHTING SYSTEM FOR OVERHEAD GUIDE SIGNS 14-57
1415 - LIGHTING SYSTEM FOR GROUND MOUNTED GUIDE SIGNS 14-59
1416 - INSPECTION AND TESTING OF LUMINAIRES FOR UNDERPASSES AND FOR GUIDE SIGNS 14-60
1417 - SERVICE CUT-OUTS 14-60
1418 - CONTROL CABINETS/FEEDER PILLARS 14-63
1419 - FOUNDATIONS FOR LIGHTING CONTROL CABINETS/FEEDER PILLARS 14-67
1420 - SAFETY SWITCHES 14-68
1421 - JUNCTION BOXES WITHIN ABUTMENT WALLS FOR UNDERCROSSING LIGHTING 14-68
1422 - FINAL ACCEPTANCE INSPECTION 14-69

SECTION 15: LANDSCAPING AND IRRIGATION WORKS 15-1

1500 - GENERAL 15-1
1501 - LANDSCAPING WORKS 15-1
1502 - PIPES, VALVES AND FITTINGS FOR IRRIGATION WORKS 15-1
1503 - EXCAVATION & PREPARATION OF TRENCHES FOR IRRIGATION WORKS 15-1
1504 - PIPEWORK, VALVES AND FITTINGS FOR IRRIGATION WORKS 15-2
1505 - VALVE CHAMBERS FOR IRRIGATION WORKS 15-2
1506 - ANCHORAGES FOR IRRIGATION WORKS 15-2
1507 - CONNECTIONS TO EXISTING MAINS FOR IRRIGATION WORKS 15-3
1508 - REMOVAL AND RECOVERY OR DISPOSAL OF EXISTING MAINS, VALVES AND FITTINGS FOR IRRIGATION WORKS 15-3

SECTION 16: TRAFFIC CONTROL SYSTEM 16-1

1600 - GENERAL 16-1
1601 - GENERAL REQUIREMENTS 16-5
1602 - CONTROLLERS 16-9
1603 - SIGNAL HEADS AND SUPPORTS 16-53
1604 - DETECTORS 16-61
1605 - CABLES AND WIRING 16-79
1606 - DUCTS AND UNDERGROUND STRUCTURES 16-83
1607 - INSTALLATIONS OUTSIDE THE ATC AREA 16-83
1608 - INSTALLATION AND ERECTION OF AUTOMATIC TRAFFIC SIGNALS 16-85
1609 - POWER SUPPLY TO CONTROLLERS 16-85
1610 - INSTALLATION OF CONTROLLERS 16-86
1611 - INSTALLATION OF SIGNAL HEADS AND SUPPORTS 16-86
1612 - INSTALLATION OF VEHICLE DETECTORS 16-88
1613 - INSTALLATION OF CABLES AND WIRING 16-91
1614 - INSTALLATION OF DUCTS AND UNDERGROUND STRUCTURES 16-92
1615 - INFORMATION, TESTING AND COMMISSIONING 16-93
1616 - MEASUREMENT AND PAYMENT 16-95

1617 - OVER-HEIGHT VEHICLE DETECTION SYSTEM 16-95
1618 - RAMP METERING 16-99

SECTION 17: UTILITIES STRUCTURES 17-1

1700 - GENERAL 17-1
1701 - REMOVAL AND REINSTATEMENT OF EXISTING ROADS 17-2
1702 - DUCT CROSSINGS 17-7
1703 - MANHOLES AND CHAMBERS 17-10
1704 - CULVERTS 17-14

SECTION 18: MAINTENANCE AND PROTECTION OF TRAFFI 18-1

1800 - GENERAL 18-1
1801 - TRAFFIC CONTROL DEVICES 18-1
1802 - APPLICATION OF TRAFFIC CONTROL DEVICES 18-5
1803 - TRAFFIC SAFETY SUPERVISOR 18-9
1804 - LIMITATION OF OPERATIONS 18-10
1805 - MAINTENANCE OF ACCESSES 18-11
1806 - TEMPORARY, TOTAL OR PARTIAL CLOSURE OF ROADS 18-11
1807 - DETOURS AND DIVERSIONS 18-12
1808 - PORTABLE ENERGY ABSORBING TERMINAL (E.A.T.) SYSTEMS 18-16
1809 - MEASUREMENT AND PAYMENT FOR MAINTENANCE AND PROTECTION OF TRAFFIC 18-17

SECTION 19: TIMBER STRUCTURES 19-1

1900 - GENERAL 19-1

SECTION 20: GAS PIPELINE CONSTRUCTION 20-1

2000 - GENERAL REQUIREMENTS 20-1

SECTION 21: TELEPHONE WORKS 21-1

2100 - GENERAL 21-1
2101 - CIVIL WORK INSTALLATION 21-2

SECTION 22: SANITARY SEWER WORKS 22-1

2200 - GENERAL 22-1
2201 - REMOVAL OF EXISTING PAVEMENT AND OBSTRUCTIONS 22-1
2202 - EARTHWORKS 22-1
2203 - PIPE LAYING AND CONNECTIONS 22-2
2204 - CONCRETE WORKS FOR PIPE LAYING 22-2
2205 - CONCRETE WORKS FOR MANHOLES AND CHAMBERS 22-2
2206 - PIPELINE CONSTRUCTION BY NON-DISRUPTIVE METHODS (MICROTUNNELING) 22-2
2207 - TESTING INSTALLED PIPELINES 22-3
2208 - MODIFICATION OF EXISTING MANHOLES 22-3
2209 - PROTECTION OF STRUCTURES 22-3

SECTION 23: MECHANICALLY STABILISED EARTH RETAINING WALLS 23-1

2300 - DESCRIPTION 23-1
2301 - MATERIALS 23-2
2302 - CONSTRUCTION REQUIREMENTS 23-6

2303 - MONITORING 23-7
2304 - MEASUREMENT AND PAYMENT 23-9

SECTION 24: PILING 24-1

2400 - GENERAL 24-1
2401 - TIMBER PILES 24-7
2402 - PRECAST PRESTRESSED CONCRETE PILES 24-9
2403 - CAST-IN-PLACE CONCRETE PILES 24-10
2404 - STEEL PILES 24-15
2405 - MEASUREMENT AND PAYMENT 24-17
2406 - PILE TESTING 24-17

SECTION 25: GROUNDWATER CONTROL 25-1

2500 - GENERAL 25-1
2501 - EXECUTION 25-2
2502 - MEASUREMENT AND PAYMENT 25-3

SECTION 26: EXCAVATION SUPPORT AND PROTECTION 26-1

2600 - DESCRIPTION 26-1
2601 - EXECUTION 26-3
2602 - MEASUREMENT AND PAYMENT 26-8

SECTION 27: PUMPING STATIONS 27-1

2700 - GENERAL 27-1
2701 - MATERIALS 27-2
2702 - EQUIPMENT 27-9
2703 - CONSTRUCTION REQUIREMENTS 27-38

SECTION 1: GENERAL

100 - GENERAL

100.01 SCOPE OF THE DOCUMENT

This Document contains the general technical specification mainly for the construction of roads, structures, storm water drainage, lighting and electrical works, and utility services installations.

100.02 CONTRACT DOCUMENTS

This document shall be considered an integral part of the Contract Documents pertaining to any project.

100.03 APPLICATION OF DOCUMENT

The contents of this document shall apply to all works unless it has been expressly required by the Particular Conditions and Specification to cancel or amend some of the Clauses.

100.04 ABBREVIATIONS

Abbreviations used shall mean as follows:

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ANSI	American National Standards Institute
API	American Petrolium Institute
ASA	American Standard Association
ASTM	American Society for Testing Materials
AWPA	American Wood Preserver's Association
AWS	American Welding Society
AWWA	American Water Works association
BD	British Digest
BPO	British Post Office
BRE	Building Research Establishment (UK)
BS	British Standards
BSCP	British Standard Code of Practice
BSEN	British Standards European Norm
CIE	Commission Internationale de l'Eclairage
CBR	California Bearing Ratio
CRD	US Corps of Engineer Specifications
DIN	Deutsche Industries Norm
EPA	Environmental Protection Agency
ESI	Electric Supply Industry Standard (UK)
FSS	Federal Standard Specification
FIP	Federation Internationale de la Precontrainte
FTMS	Federal Test Method Standard
IEC	International Electrical Commission
IEE	Institute of Electrical Engineers (UK)
IPEL	Institute of Public Lighting Engineers
ISO	International Organization for Standardization
ISRM	International Society for Rock Mechanics
KSS	Kuwait Standard Specification
MEW	Ministry of Electricity and Water
MOC	Ministry of Communications
MOI	Ministry of Interior
MPW	Ministry of Public Works
SIS	Swedish Standards

100.05 RATES

Whatever is mentioned in these Specifications, to be included in the rates, shall be complementary and/or in addition to all things mentioned in the Conditions of Contract

101 - GENERAL OBLIGATIONS AND RESPONSIBILITIES

101.01 GENERAL

In conjunction with the Contract requirements specified under this Section, the Contractor's attention is directed to Document II-1, "Conditions of Contract", consisting of Part 1, General Conditions, and Part II, Conditions of Particular Application, as being applicable

101.01.1 Contractor's Facilities

Areas available to the Contractor for plant, workshops, concrete and asphalt production plants, work areas, storage areas, labour camps, site offices etc. and such other facilities required for the works, are shown in the Contract Documents.

The Contractor shall carry out all arrangements and coordinate with all relevant authorities for any land required for the Contractor's facilities. The Employer does not guarantee that the areas shown will be sufficient for the Contractor's needs.

It will be the Contractor's responsibility to make arrangements and bear all costs associated with the acquisition and use of such areas. All necessary payments for the hire of the sites shall be made by the Contractor and shall be deemed to be an incidental obligation under this Section of the Specifications. The rates for the hire of the sites will be set by the Ministry of Finance unless otherwise provided for in the Contract Documents.

The above areas will not include land for any aggregate crusher plants, other than that specified for the crushing of asphaltic pavements, and it will be the Contractor's responsibility to arrange and pay all charges for suitable land areas for such facilities.

The use of any additional or alternative land outside the project Right-of-Way limits will be subject to the approval of the relevant Authorities including the Engineer and the Kuwait Municipality. The availability of such land will be strictly limited and will be at the sole discretion of the Municipality. It shall be the Contractor's responsibility to obtain all necessary permits and approvals and to bear all costs for obtaining such additional or alternative land. The Contractor shall not be reimbursed any additional costs of whatever nature due to the cost of obtaining such additional or alternative land.

The Contractor may utilize areas within the project Right-of-Way limits for certain of his facilities. The location and usage of such areas shall be subject to the approval of the Engineer, the Environmental Protection Agency and the Kuwait Municipality.

It shall be the Contractor's responsibility to keep the Site clear of obstructions from whatever cause for the duration of the Contract.

101.01.2 Special Measures for Control of Dust and Noise from Construction Plants

The Contractor shall take special measures to alleviate the nuisance associated with operation of aggregate cement coating plants, concrete and asphalt plants.

Measures taken will be subject to approval by the Engineer and as a minimum will include:

a. Paving entry and exit roads.

b. Paving or stabilizing plant areas subject to regular use by construction, loading or hauling equipment. Stabilization shall be with suitable oils, bitumen or chemicals.

c. Containment of Portland cement dust through use of sealed delivery and storage facilities. Bag cement can be used only with special permission and where effective equipment and methods are used to contain the

dust.

d. Sprinkling stockpiles with water during loading operation when directed by the Engineer for control of dust. Also controlling dust during excavation and backfilling operations by suitable means.

e. When designated on the Drawings, the whole of the batching plant, including sand and aggregate storage bins and all stockpiles, shall be totally enclosed in a dust and weatherproof building. The Contractor shall design the building including all mechanical and electrical services to comply with the local laws regarding environmental conditions. The Contractor's proposals shall be submitted to the Engineer for approval prior to construction of the building

The cement silos may be designed to be located outside the building; however the Contractor shall demonstrate to the satisfaction of the Engineer that the proposed measures for control of dust from the silos comply in all respects with local laws regarding environmental conditions.

The Engineer shall decide what additional measures may be required to minimize the dust nuisance associated with the operation of concrete plants and the Contractor shall implement such additional measures without delay.

Dust control measures shall be properly maintained as necessary throughout the period of plant operation. Failure to provide or maintain the necessary dust control facilities will be cause for suspension of concreting operations.

No separate measurement or payment shall be made for such special measures, but considered subsidiary works, the cost of which shall be deemed to be included in the Contractor's overall price.

101.02 LAND AND SERVICES FOR ENGINEER'S SITE OFFICE FACILITIES

Areas of land which shall be used by the Contractor for setting the Engineer's Site Office Facilities will be shown in the Contract Documents. All necessary payments for hire of the areas of land shall be made by the Contractor and shall be deemed to be an incidental obligation under this Section of the Specification. The rates for the hire of the areas of land will be set by the Ministry of Finance unless otherwise provided for in the Contract Documents.

The Site Office Facilities shall be as specified in the Particular Conditions of Contract.

102 - SPECIAL CONDITIONS FOR SAFETY REGULATIONS FOR INDIVIDUALS, PROPERTIES AND UTILITIES

102.00 DEFINITIONS

"Utilities" shall mean services ranging from the water, gas and oil supply networks electrical and telephone networks, poles, pylons, lighting columns and traffic signals, stormwater drainage and sewage networks as well as roads, gardens, squares, trees and other public or private services.

102.01 MAINTENANCE OF TRAFFIC

Unless otherwise provided, the Contractor shall keep all existing roads and accesses affected by the project construction open at all times. The road and accesses shall be kept clear at all times including clearing sand accumulated by natural causes and maintained in a condition that traffic will be adequately and safely accommodated. The Contractor shall pay particular attention to the maintenance of access whether by vehicle or pedestrian to businesses, parking lots, residence and other facilities whether public or private. These requirements shall apply throughout the entire Contract period.

Subject to the approval of the Engineer and other Relevant Authorities, the Contractor may bypass traffic over detours shown in the Contract Drawings. Where the Contractor proposes alternative layouts for the detours shown in the Contract Drawings, he must prepare his drawings to the same level of detail and obtain the approval of other Relevant Authorities and of the Engineer. The cost for constructing such approved detours including Traffic Control Devices will be measured and paid for as provided in Section 18 (Maintenance and Protection of Traffic) of these Specifications.

The construction of other detours and access roads required for the proper maintenance and protection to traffic

and which are not provided for in the Contract Drawings are the responsibility of the Contractor. This includes the preparation of detour and access proposals in sufficient detail for approval by the Engineer and where necessary by other Relevant Authorities. No extra payment will be made for this work except for the provision of Traffic Control Devices which shall be measured and paid for in accordance with Section 18 (Maintenance and Protection of Traffic) of these Specifications.

102.02 DRAWINGS

The Employer shall undertake to supply the Contractor with drawings and all data regarding the works and the Contractor shall, prior to commencement of the work, obtain details required from Public Authorities whose services might be affected by the Works.

102.03 SERVICES/COORDINATION

The Contractor shall before proceeding with the works notify other Ministries and Authorities whose services might be affected by the Works regarding his programme and/or any other amendment therein and obtain their approval. He shall also submit every two weeks details of the works contemplated for execution in order to enable the Service Authority to inspect and/or to indicate their services on the site and/or to take any measures deemed necessary. The Employer shall assist the Contractor to co-ordinate with the other Ministries and Authorities with a view to expediting obtaining the required details. The programme should not be altered without the approval of the relevant service Authority.

The Contractor shall curtail his activities in the areas where the services are being relocated by others until the relocation work is complete.

The Contractor must ensure that he obtains any work or excavation permits from the Services Ministries. Authorities and Companies necessary to allow him to carry out construction works in the vicinity of existing services.

102.04 EXISTING SERVICES

102.04.1 General

The Contractor shall notify the Ministries, Authorities and Companies which have certain services at the Site of Works or works in progress at the Site of the Works at least two weeks before he desires to carry out any work, near, above or under the services of these Ministries, Authorities and Companies and he shall submit a detailed programme for each area on which the work shall be commenced and the anticipated date of commencement in addition to a report, signed by the Engineer, the Engineer of the Ministry, Authority or Company to whom the services belong and the Contractor's representative, confirming this Notice of Intent.

The Contractor must also ensure that he obtains any work, excavation or other permits to allow him to carry out construction work in the vicinity of existing services.

The extent, position, size and type of services shown on the Drawings have been based on information extracted from the records of the various Ministries, Authorities and Companies and must be regarded as approximate only. The Contractor shall contact the Ministries, Authorities and Companies to obtain the necessary information and drawings to determine the exact locations of the services which will be affected by the Contractor's work.

It should be emphasised that all the locations of services shown on the drawings are for guidance only and do not necessarily show the exact locations, depths and spacings, nor the smaller branches of services which are not normally indicated on such drawings. The Contractor shall uncover by hand digging and verify locations of all services in accordance with any special requirements of the Service Ministry, Authority or Company concerned.

It should be noted that the Contractor shall not be allowed to work in any area where services are still covered and the Engineer shall have the right to stop work in any part of the Works where the Contractor fails to take the necessary measures to uncover these services and the Contractor shall not claim for compensation in time or money.

The Contractor before covering any exposed services must notify the relevant Authority to examine the work location, to check the soundness of the utilities and to supervise the covering process. This supervision does not relieve the Contractor from any liability in case it is proven that his work has affected the public utilities.

The Contractor shall refer to and comply with law No.18 for year 1978 regarding Safety Regulations and protection of the public utilities and the resources of public wealth amended with law No.56 for year 1980 and decree of Safety Regulations for people, property, public utilities issued on 5 July 1980 and decrees No. 94/83 and 95/83 issued on behalf of Municipality's Director General, published in the Official Gazette (Kuwait Al yum) No. 1507, and decree No.1 for year 1997 regarding the list of costs for repairing the utilities and services of Public Authority for Agricultural Affairs and Fish Resources (PAAFR) issued in the Official Gazette, and all other current Regulations and Specifications of Ministries, Authorities and Companies before commencing any works adjacent to equipment, plant, cables, etc. The above requirement will not relieve the Contractor of responsibility for taking every precaution to avoid damage to equipment, plant, cables, etc., and he will be held responsible for the cost of repair of all damage and other liability claims in accordance with the Conditions of Contract and Specifications. Payment for complying with the above requirements will be deemed to have been included in the rate for Works included in the Bills of Quantities.

In addition to what has been stipulated in the Contract Documents for safety regulations for individuals, properties and public utilities, the Contractor must take all necessary precautions when excavating and opening trenches to protect public utilities such as electrical network, lighting, telephone, water and irrigation pipes, gas, stormwater and sewers, etc., according to the following:

i. Avoid the use of machinery in excavation works if these machines affect the public utility network because of its closeness, or it is perpendicular to the excavation. The Contractor is not allowed to demand any financial compensation or time extension to perform the works for not using any machinery.

ii. The utilities which are along or perpendicular to the excavation are considered close to the excavation if the work can affect these utilities and leads to loosening of the soil underneath any of these utilities during excavation.

102.04.2 Working Adjacent to Ministry of Electricity and Water High Tension Transmission Lines

a. The Contractor shall refer to and comply with the current Regulations and Specifications of the Ministry of Electricity and Water whenever work is carried out or plant, equipment, gear, machinery, apparatus, appliance or any part thereof, e.g. jib of crane, hoist, rope, load, etc., is used adjacent to the Ministry's High Tension Overhead Transmission Lines.

b. The above requirements will not relieve the Contractor of any responsibility for taking every precaution to avoid risk to persons or damage to transmission lines and pylons or other property and he will be held responsible for the cost of repair of all damage.

c. No separate payment for complying with the requirements of this Clause will be made and any associated costs should be taken into consideration by the Contractor when preparing his tender.

102.05 DAMAGE TO UTILITIES AND PROPERTIES

In the event of any damage to utilities or properties as a result of work carried out by the Contractor or his agents, or by the Sub-contractors or their Agents, employees, the Contractor shall be responsible for indemnification against such damages.

A committee is formed from the Authority owner of the work and a representative from the side receiving the damage to assess the extent of the incurred damages in the presence of the Contractor or his representative. The absence of the Contractor or his representative cannot prevent the committee from pursuing the investigation.

102.06 PAYMENT FOR DAMAGES TO UTILITIES AND PROPERTIES

The Employer shall have the right to deduct the actual costs charged to the Employer from monies due or becoming due to the Contractor without it being necessary to serve a notice or warning or to take any legal action and the Contractor shall not be entitled to object, refrain from or suspend the work on account of such deduction.

The actual costs charged will be those received in any claim by individuals or companies which relate to the damage of private property or those assessed by the relevant Authority for the damage of their utilities.

Deductions shall be made from the Contractor's Payment Certificates for damages to utilities and properties. Such deductions shall be based initially on the charges as presented by the Owner of the damaged utility or

property. When the Safety Committee established under Amiree Decree Number 56, 1980 has established the final amount(s) of any deductions(s) to be made, the amounts as initially deducted will be adjusted if necessary, and the required adjustment (plus or minus) will be made via subsequent Payment Certificates.

According to the Traffic Laws, the committee shall evaluate the compensations according to the approved tables of the Safety Committee for damages relevant to traffic.

If monies due to the Contractor of guarantees deposited by him are not sufficient for settlement of the required amounts, then the balance of such amounts shall be considered as a debt which must be settled.

102.07 RESTRICTIONS ON MECHANICAL PLANT

The Contractor shall ascertain that there are no services or properties on the site or work which will be affected by the plant he intends to use. He shall not claim any compensation or extension to the work execution period as a result of not utilizing mechanical plant.

102.08 USE OF EXPLOSIVES

In the event of the use of explosives, the Contractor shall obtain all necessary approvals from both Ministry of Interior (MOI) and Ministry of Defense (MOD). Necessary precautions and measures shall be taken for suspending traffic, pedestrians, animals and vehicles on the site or in its vicinity at the time of blasting. The Contractor shall bear full responsibility for any casualties and damages to utilities, persons and properties etc as a result of using explosives.

If explosives are allowed to be used, then they should be stored in a secure place, and the blasting should be carried out in the presence of the police /military personnel.

102.09 SUPPORT TO EXCAVATIONS

In accordance with relevant sections of these Specifications the Contractor shall provide, install and maintain supports to the sides of all excavations and trenches in a way that prevents the sides from collapsing or from affecting in any way whatever the surrounding utilities and properties, whether as a result of collapse of the sides of excavation and/or as a result of sliding.

102.10 PUBLIC SAFETY AND CONVENIENCE

The Contractor shall not deposit the earth obtained from excavation and/or store up or deploy equipment, tools and plant necessary for the work in locations which affects the safety of the public or public services or properties and/or in such a way that impedes traffic or pedestrians and any other works of public authorities or private concerns.

The Contractor shall backfill promptly all trenches and open cuttings to the standards required by the Engineer or relevant Authority.

102.11 DISPOSAL OF SURPLUS BUILDING MATERIALS, RUBBISH AND TEMPORARY INSTALLATIONS

The Contractor shall keep the construction site neat and clean to the satisfaction of the Engineer by daily removal of surplus building materials, rubbish, temporary installations and by periodic cleaning to remove wind blown sand and debris. All arisings from such cleaning operations shall be removed from the site to public dumping areas indicated by the Municipality. The Contractor shall obtain a certificate from the Municipality certifying that the site is clear prior to the issue of the Final Payment Certificate, and prior to relieving him from his obligations. No separate payment shall be made for keeping the site neat and clean.

Rubbish and debris deposited on the site after the date of Tender by sources other than the Contractor shall also be removed by the Contractor when instructed by the Engineer. Such work shall be treated as a Variation.

On Final Completion of the works the Contractor shall clear away and remove from the Site all remaining constructional plant, surplus materials, rubbish and temporary works of every kind and leave the whole of the site and Works clean and in a workmanlike condition to the satisfaction of the Engineer.

102.12 EXCAVATION IN ROADS AND PUBLIC AREAS

If it becomes necessary for the Contractor to excavate in existing roads, pavements, squares or public gardens, he shall obtain the approval of the Engineer and MOI's Traffic Department and shall observe the following requirements:

a. The Contractor shall, prior to commencement of such work, agree with the Engineer and other relevant Authorities to provide roadways serviceable for traffic for the duration of the work.

b. If in the opinion of the Engineer temporary road closures, road diversions or construction detours are required, the Contractor shall comply with the relevant Sections of these specifications, otherwise the Contractor shall :

   i. execute the work in two stages (2 halves) to avoid stopping the traffic, if the required work is at right angle to the direction of traffic. If this is not feasible, the Contractor shall, before starting the works, and with the approval of the Traffic Department of MOI, prepare a temporary road suitable for traffic during execution of the works.

   ii. execute the work at the time when the traffic is least congested. If in the opinion of the Engineer the work may result in unacceptable inconvenience to traffic, the work shall be carried out during the night time.

   iii. provide safe pathways not less than 1.20m wide for pedestrians and traffic lanes not less than 3.5m wide for vehicles, widened at 100m intervals to provide for waiting areas, and traffic is controlled by means of traffic signals.

   iv. provide in all cases, fencing, signs, light signals, floodlights, and watchmen to ensure that no mishaps will befall the public or properties in such locations.

   v. reinstate to original condition and make good without delay.

c. In case the Contractor needs to stop the traffic temporarily in some roads, streets or squares, he shall avoid closing distances more than 0.5km, and he must make sure to provide temporary access roads or temporary passages not less than the width described in (iii) above, this according to prior agreement with the Traffic Department of MOI.

d. The Contractor must not excavate sidewalks, roads, streets, squares in residential and commercial areas thus preventing access to residencies and commercial premises without the approval of the Engineer. In situations where excavation is necessary in front of residential and commercial areas, the Contractor must provide 3m passage for entrance to the residential and commercial premises along the length of the excavated area. The Engineer shall determine the number of passages which are required.

e. All work shall be carried out in accordance with Section 18 (Maintenance and Protection of Traffic) of these Specifications.

102.13 WORKS TO BE KEPT DRY

The Contractor shall pump out underground water and/or percolating water which he might encounter in the excavations and cart away such water to places indicated by the Engineer. The Engineer may allow the disposal of such water in rainwater gullies providing there is no technical hindrance.

102.14 TEMPORARY FENCING

Unless otherwise directed by the Engineer all open excavations and other hazardous areas shall be enclosed by temporary fencing.

Temporary fencing shall be as detailed in the Standard Drawings of the Contract Documents.

The Ministry of Public Works may furnish some or all of the temporary fencing panels. It shall be the Contractor's responsibility to collect the panels from the designated Ministry of Public Works store, load and transport to the site of the Works, unload and install, move and reinstall, load and transport back to Ministry of Public Works store.

Should the Ministry of Public Works be unable to furnish sufficient or any temporary fencing panels, the Engineer will instruct the Contractor to provide such as are required.

In all case, locations of the temporary fencing proposed by the Contractor shall be submitted to the Engineer for approval. The Contractor shall not commence any works until the associated temporary fencing is erected and the installation has been approved by the Engineer.

Damaged sections of temporary fencing shall be repaired or replaced promptly to maintain at all times the standard of fencing and installation as initially approved. Temporary fencing shall not be removed from any location without the prior approval of the Engineer.

On completion of the Contract all temporary fencing panels, whether provided by the Ministry of Public works or by the Contractor, shall become the property of the Employer and shall be refurbished to a condition similar to new and delivered to a Ministry of Public Works storage area as directed by the Engineer.

Temporary fencing shall be measured by the metre run as determined by the length of panel times the number of panels initially installed

Measurement shall be once only for the Contract Period for:

a. as provided by Contractor and installed

b. as provided by Ministry of Public Works and installed

Payment shall be made for each metre run of temporary fencing (measured as described above) initially installed by the Contractor and approved by the Engineer. Payment shall include for, collecting, providing, installing, maintaining, moving and reinstalling, repairing or replacing damaged sections and removing from site when no longer required.

102.15 FAILURE OF THE CONTRACTOR TO COMPLY

Should the Contractor fail to comply with one or more of the requirements of Clauses 102.01, 102.09, 102.10, 102.11, 102.12, and 102.14 of these Specifications he will be given written notification by the Engineer of the default and shall commence execution of the work required to comply with the requirements of this Clause within 24 hours of receipt by him or such written notification.

Should the Contractor fail to commence execution of such works to the satisfaction of the Engineer within 24 hours after receiving written notification by the Engineer to do so he shall incur a penalty. Such penalty will be KD 500 for the first day or part day of non-compliance with the notification and such penalty will increase cumulatively by KD 500 per day for each additional day or part day of non-compliance.

Should any penalty applied under this Clause apply for seven or more consecutive days the Engineer may suspend all work on the Contract, and the Employer may execute (or have executed by others) the work directed by the previously issued written notification and deduct all costs incurred from any amounts due or becoming due to the Contractor and/or shall recover the said amount as a debt due for payment by the Contractor. An additional 50% shall be added to the direct costs of such work as executed by the Employer (or others) to cover costs of overheads, supervision, etc. The penalty described above shall continue during the suspension period. The suspension of work shall not relieve the Contractor of his responsibility to complete the Contract on time nor will he be entitled to any additional compensation or an Extension of Time for Completion because of this suspension.. The suspension of all work on the project shall automatically be rescinded on completion of the notified works to the satisfaction of the Engineer.

The penalty will be in addition to any other penalties specified in the Contract Documents.

103 – ENGINEER'S SITE OFFICE FACILITIES

103.01 ENGINEER'S SITE OFFICES

Refer to Particular Conditions of Contract for the requirements of Engineer's Site Offices and Temporary Accommodation.

103.02 SURVEYING EQUIPMENT

The Contractor shall provide and maintain the surveying equipment for the use of the Engineer's staff, as set out below and in the Particular Specifications.

All surveying equipment shall be new when supplied and shall be fully maintained and repaired by the Contractor to the satisfaction of the Engineer.

Before any item is removed for maintenance or repair a similar approved item shall be provided as a temporary replacement unless otherwise agreed by the Engineer.

Prior to acceptance of any Surveying Equipment the Engineer shall inspect the said equipment for compliance with these Specifications. If the Engineer is satisfied that the Equipment is in compliance with the Specification he shall issue a letter of acceptance of the Equipment.

The Contractor shall complete the provision of the Surveying Equipment to the Engineer's satisfaction of the Date of Enterprise. Should the Contractor fail to provide any of the Surveying Equipment within the specified period, he shall incur a penalty of Kuwait Dinars One Hundred and Fifty (KD 150/-) per day until all the Surveying Equipment specified is provided to and accepted by the Engineer.

The Contractor shall provide the equipment to be inspected by the Engineer at any time during the project life span and shall be responsible for the safety of his personnel and equipment inside and outside the project area.

Upon completion of all construction works and on written instruction of the Engineer, the Surveying Equipment shall be removed from the site by the Contractor.

30 metre steel tape 50 metre steel tape 5 m pocket tape 30 metre glass fibre plastic tape	
Ranging rod	20
Surveying pins	as required
Optical square	6
Lump hammer 1.8 kg (4 lbs)	6
Sledge hammer 3.2 kg (7 lbs)	2
Portable "surveying" safety sign	12
Surveyors field books	as required
Surveying marking materials	as required
Surveying umbrella	7
Torch (9 volt)	6
Plumb bobs and lines	4
String chalk lines	as required
Safety harness	4
1 metre spirit level	6
1 metre folding measure	8

All survey equipment to be as noted or equal approved by the Engineer.

103.03 MEASUREMENT AND PAYMENT

No separate measurement and payment will be made for all the "Engineer's Site Offices Facilities" nor for the "Temporary Accommodations" nor for their maintenance for the duration of the Contract nor for "Surveying Equipment" but considered subsidiary works, the cost of which shall be deemed to be included in the Contractor's overall price.

104 - MONTHLY PROGRESS PHOTOGRAPHS

Refer to Particular Conditions of Contract for the requirements of Monthly Progress Photographs. No separate measurement and payment will be made for the "Monthly Progress Photographs but considered subsidiary works, the cost of which shall be deemed to be included in the Contractor's overall price.

105 - SIGN BOARDS

Refer to Particular Conditions of Contract for the requirements of Sign Boards. No separate measurement and payment will be made for the "Sign Boards" but considered subsidiary works, the cost of which shall be deemed to be included in the Contractor's overall price.

106 - TEMPORARY WORKS

In addition to temporary works described elsewhere in the Contract or required by insurance companies or underwriters the Contractor shall provide for the following temporary works at his own expenses.

Telephone – Allow for providing necessary telephones for the offices of the Engineer for his sole use, pay all installation, rental and removal charges and all local calls made in connection with the works

Accommodation for Workmen – Allow for providing sheds and workshops for the use of the workmen on the Site with an adequate supply of pure drinking water.

Site Storage Accommodation – Allow for providing and maintaining all necessary temporary weatherproof buildings for storage and protection of plant, goods and materials on Site and other work that may be brought or executed on the Site. All sheds are to have floors raised from the ground. Notwithstanding the above it shall remain the Contractor's sole responsibility to protect all materials until the completed works are handed over to the Employer.

Storage on Site – The areas permitted for use by the Contractor shall be used under conditions to be approved by the Engineer and other areas shall not be used without express permission of the Engineer.

Temporary Stormwater Drainage - Allow for ensuring that the whole of the excavation and Site are kept free from the risk of stormwater flooding and providing such temporary ditches, gullies and the like as may be necessary and for subsequently backfilling such excavations. Any damage arising from non-compliance with this Clause is to be made good at the Contractor's own expense.

Scaffolding and Plant - Allow for providing all scaffolding, hoists, tackle and other plants, profiles, templates, centerings and equipment generally required for the proper, safe and efficient execution of the works and providing all labour and things required by the Engineer for testing and measuring the works and for weighing, measuring or testing the efficiency of any portion of the Works. The Contractor is particularly to note that scaffolding, staging and the like is to be provided for the execution of his own work including that required solely for the execution of work by sub-contractors. Also allow for providing all gangways, walkways, planking, decking, ladders, temporary platforms, etc., necessary to construct and afford access to or between all parts of the works. All scaffolding and plant shall be erected and used in accordance with the applicable local laws.

Streets and Sidewalks – The Contractor shall protect streets and sidewalks and shall repair damage caused by himself. The Contractor shall comply with local rules and regulations in connection with the use of streets. The Contractor shall protect all private roads and walks, and shall maintain them during the course of the Work. He shall repair all damage to them caused by himself.

Water for the Works – Allow for providing temporary water supplies or water for the Works and for payment of all other fees and charges and for providing temporary storage tanks and mains, pumps, etc, on the Site.

Lighting and Power – Allow for providing temporary lighting and power lines for the Works except where payment is specifically provided for elsewhere in the Contract. The Contractor shall also be responsible for payment of all other fees and charges for providing temporary mains to the Site.

Existing Services - The Contractor is to include for all temporary works to maintain and protect existing power, lighting, water and telephone services while the Works are being executed. Temporary shutdown of services shall only be made with the prior approval of the Engineer.

Existing Installations – Allow for protecting and maintaining all pipes, ducts, and cables met in excavations, for keeping all ditches, gullies and channels clear and unobstructed and for making good any damage caused to public or private roads, paths, kerbs and drains and paying all costs and charges incurred.

Weather Protection - The Contractor shall provide protection against weather, rain, wind, storms, or heat to maintain the Works, materials, apparatus, and fixtures free from injury or damage. Works likely to be damaged shall be covered at the end of each day's work. The Contractor shall refer to all Sections of the General Specifications and the Supplements to the General Specifications for specific protection required under the Contract.

Temporary Works Generally – The Contractor shall ensure that all temporary electrical, water and other temporary installations are executed in accordance with the requirements of the authorities concerned.

All temporary works are to be properly and adequately maintained and on completion of the Contract or when directed by the Engineer shall be cleared away by the Contractor and all disturbed works made good. Any works damage by failure to provide proper protection shall be removed and replaced with new work at the Contractor's expense.

107- ENGINEER'S TRANSPORT

The Engineer's transport shall be as specified in the Particular Conditions of Contract..

108 - SITE ACCESS

108.01 TEMPORARY ACCESS ROADS

The Contractor shall arrange for, construct, maintain and afterwards remove and reinstate any access required for and in connection with the execution of the Works.

Reinstatement shall include restoring the area of any access route to at least the degree of safety, stability and drainage that existed before the Contractor entered the Site.

108.02 SITE ENTRY

The Contractor shall notify the Engineer in writing 14 days in advance of his intentions to start work. If construction of the Works includes operations in two or more areas, such notifications shall apply to each area.

Working areas for which access is subject to time constraints shall be as detailed in the Contract Documents.

Hazards known to the Employer in the working areas are detailed in the Contract Documents.

The Contractor shall keep records of the dates of his entry onto and departure from all areas included in the Works, together with the dates of the erection and removal of temporary hoarding, and shall furnish copies of these records when required by the Engineer.

The Contractor is to note that MOI's Traffic Department has restriction on the use of certain roads by heavy vehicles during certain hours of the day/night, and he must abide by these restrictions and take them into consideration in planning and programming his work.

109 - PROTECTION OF THE WORKS

109.01 GENERAL PROTECTION

The Contractor shall take full responsibility for the care and protection of the Works and temporary works against damage of any kind for the duration of the Contract.

In the event of any damage to the Works or temporary works, the Contractor shall undertake all necessary repairs or replacement, at the Engineer's discretion, at his own cost.

109.02 PROTECTION OF FINISHES, EQUIPMENT AND SURFACES

The Contractor shall take full responsibility for the protection of finishes, equipment and surfaces that form part of the Works. Protective coatings and wrappings shall be left on items for as long as possible and practicable.

In the event of any damage to finishes, equipment or surfaces, the Contractor shall undertake all necessary repairs or replacement, at the Engineer\s discretion, at his own cost.

109.03 PROTECTION OF OTHER WORKS

The Contractor shall take all necessary precautions to avoid causing any unwarranted damage to roads, land, properties, trees and other features and, during the currency of the Contract shall deal promptly with any complaints by owners or occupiers.

Where any portion of the Works is close to, across, or under any existing apparatus, the Contractor shall temporarily support and work round, under or adjacent to the apparatus in a manner designed to avoid damage, leakage or danger, and to ensure uninterrupted operation of the apparatus.

Should any leakage or damage be discovered, the Contractor shall at once notify the Engineer and the owner concerned, as appropriate and the Contractor shall afford every facility for the repair or replacement of the apparatus affected.

The Contractor shall notify the Engineer in writing immediately following any damage or injury resulting from the execution of the Works.

The Contractor shall be responsible for all costs associated with the repair of other works due to damage caused by the Contractor or his Sub-Contractors, Agents or Servants.

109.04 WATCHING AND LIGHTING

The Contractor shall provide all watching, lighting and any other facilities day and night as necessary for the protection of the public and workers.

The Contractor shall provide all watching and lighting and everything else necessary by day and night for the protection of goods, materials, plant and properties at the Site to whomsoever belonging.

The Contractor shall take all necessary and practicable precautions to prevent trespass onto the Site whether it is intentional or unintentional.

The Contractor shall provide watchmen at the Site at all times outside of normal working hours.

110 - PROJECT MEETING

110.01 PRE-CONSTRUCTION MEETING

A pre-construction meeting shall be held at the Site. The Engineer shall set the date and time of the meeting and shall notify the Contractor accordingly.

The Employer, the Engineer and the Contractor and their respective representatives shall attend this meeting.

The Engineer shall provide the agenda a minimum of three (3) working days prior to the meeting.

Contractual topics of discussion will include, but not necessarily be limited to, the following:

- Date of signing Contract Agreement
- Contract sum
- Starting instructions
- Commencing date
- Contract Period
- Maintenance period
- Penalties

Contractor’s Obligation topics of discussion will include, but not necessarily be limited to, the following:

- Performance Bond
- Program of Works

- Insurances

Site related topics of discussion would include, but not necessarily be limited to, the following:

- Possession of Site / Take Over Site
- Access by other contractors and agencies
- Engineer's site facilities
- Contractor's site facilities
- Traffic diversions
- Maintenance of existing access
- Sub-contractors and suppliers
- Project signboards
- Site safety
- Site personnel
- Site inspections
- Materials on site and material testing
- Working hours (Fridays/holidays/overtime working)
- Quality assurance
- Co-ordination

Drawing and communication topics of discussion will include, but not necessarily be limited to, the following:

- Project correspondence
- Contract Documents
- Daily reports
- Weekly reports
- Monthly reports
- Method statements
- Progress meetings
- Material approvals
- Submittals

110.02 PROGRESS MEETINGS

Progress meetings shall be held once a month. The Engineer shall chair the meetings.

The time and location of the progress meetings shall be as directed by the Engineer. Where possible and practicable, progress meetings shall be held at the same time, day of the month and location.

The Engineer shall prepare the agenda and submit it to the Contractor a minimum of three (3) working days prior to the meeting.

The Engineer and his representatives and the Contractor and his representatives shall attend progress meetings. Sub-contractors may attend when involved in the matters to be discussed or resolved but only when requested by the Engineer. In addition to the attendees named herewith, the meeting may be attended, if required, by representatives of utility owners, Government departments and authorities and any other regulatory agencies having jurisdiction over the Project, and such other persons the Engineer may designate.

The Contractor shall submit a Monthly Progress Report to the Engineer at least 5 working days before the meeting. The format of the progress report shall be as directed by the Engineer.

The Contractors Monthly Progress Report shall describe in sufficient details the following items as a minimum:

<u>Part 1 - General Contract Data</u>

i. Table of Contents
ii. Site Location Plan
iii. Project Information:

iv. Contract Number
v. Contract Title
vi. Contractor's name and address
vii. Date Contract Signed
viii. Date of Enterprise
ix. Original Contract Period
x. Original Date of Completion
xi. Approved Time Extensions
xii. Revised Contract Period
xiii. Revised Date of Completion
xiv. Probable Date of Completion
xv. Contract Time Expired
xvi. Percent Time Expired (original period)
xvii. Percent Time Expired (revised period)
xviii. Original Contract value
xix. Anticipated Total Cost
xx. Anticipated percent change in Contract Value
xxi. CTC maximum allowable increase
xxii. Work completed to date
xxiii. Percent of Anticipated Total Cost
xxiv. Percent as in Contractor's Program
xxv. 85% value of materials on site
xxvi. Total of Work Completed to date and 85% of Materials on Site.
xxvii. Above as percentage of Anticipated Total Cost
xxviii. Third Party Insurance
xxix. Penalty for Delay
xxx. Other Penalties
xxxi. Mobilisation Advance
xxxii. Mobilisation Repayments to date
xxxiii. Non-specified Subcontract limitation in Contract
xxxiv. Non-Specified Subcontract percentage approved to date

Part 2 - Summary of Construction Progress

Prepare a brief description of the works executed during the month and the status to date for each section of works in the same order corresponding to the priced Bills of Quantities of the Contract and the Schedule of Values.

Where applicable, use phrases such as "No works in this category done this month," "Works in this category substantially completed," "Status remains same as reported on Monthly Report No. for (date)."

Part 3 - Appendices

- Bar Chart Progress Against Program
- Financial Progress Chart (cash flow diagram)
- Table of Variation Orders
- Table of Claims
- Table of Subcontractor's Approvals
- Table of Materials Approvals
- Contractor's Staff and Labour
- Contractor's Plant
- Safety Report

Part 4 - Progress Photographs

The Contractor shall supply the Engineer with monthly coloured, dated, photographic records, with negatives. The number of copies and size of the photographs shall be as set out in the Particular Conditions.

110.03 PRE-START-UP MEETING

A pre-start-up meeting is required prior to starting up any major component of works

Pre-start-up meetings shall be attended by the Engineer and his representatives and the Contractor and his representatives. If necessary, equipment manufacturers and suppliers shall also attend as approved by the Engineer.

The agenda for the meeting shall be provided by the Engineer a minimum of three (3) working days prior to the meeting.

Topics for discussion will include but not necessarily be limited to the following:

- Start-up and validation prerequisites
- Start-up plan and schedule
- Temporary connections
- Spare parts, chemicals, and operating fluids

Other items deemed necessary by the Engineer.

110.04 POST-CONSTRUCTION MEETING

A post construction meeting shall be held prior to Substantial Completion of the Works. Post-construction meetings shall be attended by the Engineer, the Contractor and their respective representatives.

The Agenda for the meeting shall be provided by the Engineer a minimum of three (3) working days prior to the meeting.

Topics for discussion will include but not necessarily be limited to the following:

- Discuss and resolve all unsettled matters
- Guarantees and insurance
- Schedules and procedures for final inspection process
- Correction of defects and deficiencies
- Documents required to be submitted by the Contractor
- Other items deemed necessary by the Engineer.

110.05 RECORD OF MEETINGS

The Engineer will record minutes of each meeting. A copy of the minutes shall be furnished to the Contractor within four (4) working days.

If the Contractor has any objections to the minutes he shall submit them in writing to the Engineer not more than two (2) days after they are presented to him. In the absence of an objection, it shall be understood and agreed that the Contractor accepts the minutes as true and complete record of the meeting.

110.06 SUBMITTALS

Mistakes in Information

The Contractor shall be responsible for and shall pay the extra cost, if any, occasioned by any discrepancies, errors, or omissions in submittals supplied by him, whether they have been approved by the Engineer or not.

Definitions

- Product Data and Shop Drawings: Product Data and Shop Drawings include drawings, diagrams, illustrations, brochures schedules, bills of materials and other data prepared specifically for the Works. The information may be prepared by the Contractor, his sub-contractors, supplier's or distributors, manufacturers or fabricators. The information must illustrate or describe the manufacture, fabrication, construction and installation of the Works or a portion thereof.

- As Built Survey Drawings: As-Built Surveys are topographical surveys that show changes to topography as a result of the construction of the Works. Changes to topography include the construction of new structures and roads, demolition of existing structures and roads and the like. The As-Built Survey Drawings shall form a comprehensive record of the topographical changes resulting from the construction of the Works in all respects.

As-Built Surveys shall also show all sub-surface elements of the Works. Subsurface elements include pipelines, ducts, cables, chambers, manholes and the like. The As-Built Survey Drawings shall form a comprehensive record of the sub-surface elements of the Works as constructed in all respects. In addition, the As Built survey shall show the locations of all pre-existing sub-surface elements found during the course of the works together with a note as to whether these elements were left in-situ, diverted or abandoned.

- As Built Record Drawings: As-Built Record Drawings are drawings that show the Works as constructed in all respects. They are in addition to the elements of the Works shown on the As-Built Survey Drawings.

- Manufacturer's Representative: Manufacturer's representatives are persons actively working at the manufacturer's factory with a minimum of 5 years experience. They should be familiar with the actual process of manufacturing, installing, and operating the product they represent. Sales representatives or agents are not an acceptable alternative to manufacturer's representatives.

- Temporary Works Drawings: Temporary Works Drawings are plans for temporary structures and facilities prepared by the Contractor specifically for the Works. Elements of work that may affect the safety of persons or property shall be checked and certified by an approved safety inspector. Calculations demonstrating adequacy of Contractor's design shall be submitted with the Temporary Works Drawings.

- Samples: Samples are physical examples illustrating materials, equipment, or workmanship and shall be used to establish standards by which the work will be judged.

- Manuals: Manuals are manufacturer's written installation, start-up, operating, maintenance and repair instructions. They shall include parts lists, pictures, sketches and diagrams specific to the equipment supplied.

Submittal requirements

The Contractor shall submit to the Engineer for his review and approval all drawings and data as called for in the Contract Documents or subsequently as covered by variations.

Submittals and their contents shall be properly prepared, identified, and transmitted officially or as the Engineer may otherwise direct where possible and practicable, the Contractor shall present submittals on A4 size paper.

All submittals shall be in triplicate unless otherwise specified in the Contract Documents.

Schedule of Submittals

The Contractor shall prepare and submit a list of all submittals, required by the Contract or otherwise, showing the forecast date for submission of each item within forty-five (45) days after the start of the Contract.

Drawings and data shall be submitted to meet the time schedules stipulated in the Contract Documents and where such time schedules are not specified, to meet the requirement of the approved programme. Unless specified otherwise, the Contractor shall allow not less than thirty (30) days for the review of submittals by the Engineer (excluding the time necessary for delivery or postage) and shall cause no delay in the work or the work of any other contractor.

Extension of time will not be granted because of the Contractor's failure to make timely and correctly prepared and presented submittals with allowance for the checking and review periods.

Method of Submittal

The Contractor shall deliver submittals by means of dated, signed, and sequence numbered transmittals. The transmittal shall be on the Contractor's letterhead and shall fully describe the submittal contents. Submittals are not acceptable directly from sub-contractors suppliers, or manufacturers.

In each transmittal the Contractor shall state the Drawing numbers and Specification Sections, Parts, and Paragraphs to which the submittal pertains. Accompanying data sheets, catalogues, samples and brochures shall be identified in the same manner. Where several types or models are included in a single data sheet, catalogue or brochure, the Contractor shall delete non-applicable portions or specifically indicate which portions are intended and applicable.

Contractor's Review and Approval

Every submittal shall bear the Contractor's review and approval stamp certifying that the Contractor has:

- Reviewed, checked, and approved the submittal
- Co-coordinated the contents with the requirements of the Works, the Project Documentation and any related work
- Determined and verified all quantities, field measurements, field construction criteria materials, equipment, catalogue numbers, and similar data.

Corrections and Re-submittals

The Contractor shall make all required corrections and shall resubmit corrected submittal until approved.

The Contractor shall direct specific attention in writing to revisions other than the corrections called for on previous submittals.

The Contractor shall identify each re-submittal with the sequel number of the original submittal followed by consecutive letters starting with "A" for first re-submittal, "B" for second re-submittal, etc.

Check of Returned Submittals

The Contractor shall check submittals returned to him for correction and ascertain if the corrections result in extra cost to him above that included and allowed for under the Contract Documents. The Contractor shall give written notice to the Engineer within five (5) days if, in his opinion, such extra cost results from corrections.

By failing to so notify the Engineer or by starting any work covered by a submittal, the Contractor waives all claims for extra costs resulting from required corrections.

Review and Approval

Submittals will be reviewed only for conformance with the design concept of the Project and with information given in the Contract Documents. The approval of a separate item as such shall not indicate approval of the assembly in which the item functions.

The approval of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents unless otherwise agreed with, and confirmed in writing by, the Engineer.

Any approval from the Engineer shall not relieve the Contractor of responsibility for errors or omissions in the submittals.

Incomplete Submittals

Submittals, which are incomplete, including those not correctly transmitted, not correctly titled and identified, or not bearing the Contractor's review and approval stamp, may be returned to the Contractor without review.

Conformance

Work shall conform to the approved submittals and all other requirements of the Contract Documents unless subsequently revised by an appropriate variation order, in which case the Contractor shall prepare and submit revised submittals as may be required.

Interrelated Submittals

Except where the preparation of a submittal is dependent upon the approval of a prior submittal, all submittals pertaining to the same portion of the Works shall be submitted simultaneously.

The Contractor shall not proceed with any work or related work, which may be affected by the work covered under submittals until the applicable submittals have been approved.

Site Diary

A Site Diary shall be kept on site by the Contractor and entered daily for the duration of the Contract. The diary must be entered neatly and legibly in English and should indicate all visitors to the Site and the reason for the visit. The diary shall also record the following:

- Labour on site by trade and its allocation
- Sub-contractors working on site
- Material and equipment delivered to site
- Material and equipment utilized
- Plant, equipment and tools brought on to or removed from site including hired plant
- Work progress during the day
- Oral instructions requiring written confirmation
- Temperature and weather conditions
- Details of any occurrence, which may affect the progress of the Works.

The diary shall be signed by the Contractor's project engineer and given to the Engineer's Representative on a daily basis.

The diary shall become the property of the Engineer on completion of the Works

Contractor Design Work

For all components or work shown or required in the Contract Documents to be designed or detailed or proposed (in case of any Value Engineering proposal) by the Contractor, the Contractor shall prepare the design or details or proposal as needed to successfully complete the works.

When requested to submit design calculations, the method statement and/or drawings for any temporary or permanent works, it shall have sufficient details demonstrating compliance with Contract requirements and reference Standards requirements.

When the Contractor is requested to design certain works or whole of the Works, the Contractor shall carry out, and be responsible for the design of works "drawings, calculations, and other relevant information". Design shall be prepared, signed and stamped by a chartered/licensed professional engineer who has experience in the design of the required work and who comply with the criteria (if any) required by the Employer. The said professional engineer has to be registered in the State of Kuwait, and if international, should be registered in own country and qualification certificate attested by Kuwait Embassy in Engineer's country and/or Ministry of Foreign Affairs in the State of Kuwait. Alternatively, a specialist Engineering Design Consultant firm with relevant experience could carry out the above task. The Engineering Design Consultant shall be legally registered in the State of Kuwait. International Design Consultants shall be registered with the Ministry of Planning in the State of Kuwait.

For each part of the works/Works, the prior consent of the Engineer/Employer shall be obtained to the designer and design Sub-contractor, if they are not named as such in the Contract. Nothing contained in the Contract shall create any contractual relationship or professional obligations between any designer or a design Sub-contractor, and the Employer. The Contractor holds himself, his designers and design Sub-contractors as having the experience and capability necessary for the design. The Contractor undertakes that the designers shall be available to attend discussions with the Engineer at all reasonable times during the Contract Period

The submitted documents will be reviewed by the Engineer for completeness and will be filed with project records for future reference. Any approval given by the Engineer or Engineer's Representative would not relieve the Contractor from his liability towards any design work done by his sub-consultants.

In situations where the Engineer or his Representative supervising the work suspects or is of the opinion that the Contractor's design or calculations or shop drawings relating to his design work are difficult to interpret, have shortfalls, or dangerous with high possibility of injuries, they shall be checked, signed and stamped by an independent international consultant (A Third Party), proposed by the Contractor and approved by the Engineer.

The cost of everything necessary to comply with the above requirements is deemed to be incidental to the works and included in the rates for the items listed in the Bills of Quantities, therefore, no separate payment will be

made for this work.

Drawings

Design, Working Drawings and Shop Drawings

Each submitted drawing shall be complete with respect to dimensions, design criteria materials, connections, bases, foundations, anchors, and the like, and shall be accompanied by technical and performance data and by calculations as necessary to support the information shown on the drawings.

Unless otherwise specified, each submittal shall include six (6) sets of copies and shall be submitted at least thirty (30) days prior to beginning the work to which the drawings are related. Three sets of copies will be returned to the Contractor marked to show the required corrections or approval.

Unless otherwise stated in the Contract Documentation, the Contractor shall arrange for the design, working drawings and shop drawings to be prepared in digital (electronic) format. The digital format shall be in AutoCAD format or as directed by the Engineer.

As Built Record Drawings

The Contractor shall prepare As-built Record Drawings and submit them to the Engineer for approval. Upon approval, the Contractor shall submit the required number of copies as listed in Contract Documents to the Engineer.

Unless otherwise stated in the Contract Documentation, the Contractor shall arrange for the As-built Record Drawings to be prepared in digital (electronic) format. The digital format shall be in AutoCAD format or as directed by the Engineer.

No final payment shall be made until the As-built Record Drawings are complete in all respects. The Contractor shall not be entitled to any extra payment or extension of time for the preparation of the As-built Record Drawings.

As Built Survey Drawings

The Contractor shall arrange for As-built Survey Drawings to be prepared. The Contractor shall submit one (1) set of As-Built survey Drawings to the Engineer for approval. Upon approval, the Contractor shall submit a further four (4) sets to the Engineer. All As-built Survey Drawings shall be prepared on clear white polyester film or other durable and easily reproducible medium approved by the Engineer.

Unless otherwise stated in the Contract Documentation, the Contractor shall arrange for the As-built Survey Drawings to be prepared in digital (electronic) format. The digital format shall be in AutoCAD format or as directed by the Engineer.

No final payment shall be made until the As-built Survey Drawings are complete in all respects. The Contractor shall not be entitled to any extra payment or extension of time for the preparation of the As-built Survey Drawings.

List of Materials

The Contractor shall prepare and submit a list of the materials to be used in the Construction of the Works within (60) days of the start of the Contract. The materials list shall be neatly bound and shall have an index listing the contents.

The data for each item listed shall be explicit with regard to details of the actual items being furnished and shall include sufficient information for the Engineer to determine that the products submitted conform to the requirements of the Contract Documents. Such information shall include but not be limited to:

- Manufacturer’s name and address
- Trade or brand name
- Local supplier’s name and address
- Catalogues, brochures and cuts, marked to indicate the items proposed the intended use
- Terms and conditions of the manufacturer’s guarantee and warranty
- Material inspection and testing agency

- Any other information to fully describe the item
- Supplementary information or sample(s) as may be required for approval.

Unless otherwise specified, five (5) bound copies of the materials list shall be submitted, two (2) of which will be returned to the Contractor marked to show the required corrections or approval.

Certificates

When stated in the Contract Documents or requested by the Engineer in writing, the Contractor shall submit manufacturer's certificates indicating that test results, component manufacture or installation complies with the requirements of the Contract Documents.

Manufacturer's Guarantees and Warranties

Manufacturer's Guarantees and Warranties shall be submitted prior to handover and final acceptance.

Instructions Manual

The Contractor shall submit instruction manuals covering all mechanical and electrical equipment and machinery installed in the Works as specified under Sections dealing with mechanical and electrical work.

The Contractor shall prepare and submit two (2) copies of Operation and Maintenance Manuals to the Engineer for review. The Engineer will mark up one copy and return it to the Contractor for correction if necessary. The Contractor shall submit six (6) copies of approved manuals incorporating all of Engineer's comments and corrections.

SECTION2: EARTHWORKS

200 - GENERAL

200.01 SCOPE

This work shall consist of performing all operations necessary to complete clearing, grubbing, removing, wholly or in part, within the designated limits or adjacent thereto and satisfactory disposal of debris, vegetation, buildings, fences, structures, walls, old pavement, abandoned pipe lines and any other obstructions which are not designated or permitted to remain; remove unsuitable materials, excavate selected material from the roadway and borrow pits for use as specified; the placing and compacting of selected material; structure excavation; backfilling; pervious backfill; laying geotextile material; installing geogrid; and doing all the earthwork that may be required to construct and maintain the roadway facilities.

200.02 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

D 1388 Standard Test Method for Stiffness of Fabrics, Option A
D 2167 Standard Test Method for Density and Unit Weight of Soil in place by the Rubber Balloon Method
D 2434 Standard Test Method for Permeability of Granular Soils (Constant Head)
D 2974 Standard Method of Test for Moisture, Ash and Organic Matter of Peat Materials
D 2976 Standard Method of Test for pH of Peat Materials
D 2977 Standard Method of Test for Practical Size Range of Peat Materials
D 4254 Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculations of Relative Density
D 4354 Practice for Sampling of Geosynthetics for Testing
D 4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heating Xenon Arc Type Apparatus
D 4759 Practice for Determining the Specification Conformance of Geosynthetics
D 5818 Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage
D 6637 Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-rib Tensile Method

Geosynthetic Research Institute (GRI)

GRI-GG2 Standard Test Method for Geogrid Junction Strength

AASHTO

M 145 Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
M 288 Geotextile Specifications for Highway Applications
T 2 Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Material
T 11 Amount of Material Finer than 0.075 mm Sieve in Aggregate
T 19 Density of Soil In-Place by the Sand-Cone Method
T 27 Sieve Analysis of Fine and Coarse Aggregates
T 87 Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
T 88 Particle Size analysis of Soils
T 89 Determining the Liquid Limit of Soils
T 90 Determining the Plastic Limit and Plasticity Index of Soils
T 96 Resistance to Abrasion of Small Size Coarse Aggregate by use of the Los Angeles Machine
T 100 Specific Gravity of Soils
T 104 Soundness of Aggregate by Use of Sodium Sulphate or Magnesium Sulphate
T 143 Sampling and Testing Calcium Chloride for Roads and Structural Applications

T 176 Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
T 180 Moisture-Density Relations of Soils using a 10 1b (4.54 kg) Rammer and an 18 in (457 mm) Drop
T 191 Density of Soil In-Practice by the Sand-Cone Method
T 193 The California Bearing Ratio
T 204 Unit Weight of Soil In-Practice by the Sand-Cone Method
T 205 Density of Soil In-Practice by the Rubber Balloon Method
T 217 Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester.
T 222 Nonrepetitive Static Plate Load Test of Soils and Flexible Pavement Components
T 236 Direct Shear Test of Soils Under Consolidated Drained Conditions
T 267 Determination of Organic Content in Soils by Loss on Ignition

BS

BS 5930 Code for Practice for Site Investigations

201 - MATERIALS UTILISED IN EARTHWORK CONSTRUCTION

201.01 FILL MATERIAL

The material used for filling and compacting low level areas of the roadbed, sidewalks, shoulder and drainage ditches and other areas on site shall consist of suitable material resulting from the excavation works carried out as specified elsewhere in these Specifications. In the event that such material is unsuitable or insufficient, the Contractor shall obtain and use suitable filling material from borrow pits all in accordance with the provisions hereinafter detailed.

The Contractor, prior to using material resulting from excavation for filling, shall carry out necessary field and laboratory testing at his own responsibility and expense to establish the suitability of said material for filling work, and whenever such excavated material indicates change in characteristics, the Contractor shall carry out additional testing and shall secure the Engineer's approval for its use.

201.01.1 Suitable Materials

Suitable materials for fill/embankment construction shall be of classes A-1, A-2-4, A-2-5 or A3 "when confined" groups as in AASHTO M145 and complying with Table 201.01.1 shall be used when available, except for rock fill embankments. Suitable materials of these groups (AASHTO M145) should also comply with the requirements of Table 201.01.1;

	Requirements
1	Maximum dry density not less than 1.84 t/m^3 (AASHTO T-180 Method D)
2	Organic matter not more than 1% (AASHTO T-267)
3	Gypsum content not more than 5%.
4	Liquid Limit not more than 35.
5	Maximum size not more than 1/2 of the layer thickness
6	Plasticity Index (P.I.) less than 8%
7	4-day soaked C.B.R. should not be less than 8% (AASHTO T-193) when compacted at 100% maximum dry density in accordance with AASHTO T-180 Method D.

TABLE 201.01.1 - Soil Suitable for Embankment

The 300 mm depth of embankment immediately below the top of subgrade formation level shall consist of selected subgrade material having a 4-day soaked C.B.R. of at least 20% when tested in accordance with AASHTO T193 and with a gradation and P.I. as specified under Clause 206 - "Subgrade Construction".

The 600 mm depth of embankment immediately below the 300mm thick subgrade layer shall consist of suitable material having a 4-day soaked C.B.R. of at least 15% when compacted to 95% maximum dry density in accordance with AASHTO T-180D and tested in accordance with AASHTO T-193 with a P.I. not more than 15%. If rockfill is used for the bottom 400 mm depth then these requirements shall apply to the top 200 mm

depth below the subgrade layer.

Materials underneath the top 600 mm of fill below the subgrade layer shall consist of materials having a 4-day soaked CBR of at least 8% when tested in accordance with AASHTO T 193, when compacted to 100% maximum dry density.

Areas subject to flooding and prolonged inundation of the embankment, such as at bridge and culvert sites, the material used in embankment shall conform to AASHTO M 145, Class A-1-a, A-1-b, A-2-4. Rockfill can also be used in these conditions, except for the top 600 mm of the embankment.

Where embankments are to be constructed using material classified as A3 (AASHTO M 145) or other material subject to side slope erosion or requiring confinement for stabilization purposes, the embankment plating or confining layer shall be constructed using AASHTO M 145 Class A-1-a, A-1-b, or A-2-4 materials or as otherwise approved.

The material used in rockfill embankments shall consist predominantly of rock fragments of such size that the material can be placed in layers of the thickness prescribed conforming to the requirements stated in Table 201.01.2 below:

	Requirements	
1	Maximum particle size	100mm
2	Passing 0.42mm (Sieve # 40)	25% maximum
3	Uniformity coefficient, Cu D_{60} = the Particle size at which 60% passes D_{10} = the Particle size at which 10% passes	5 minimum, where $C_u = D_{60}/D_{10}$

Table 201.01.2 - Rock Suitable for Embankment

Rockfill material shall be obtained from quarries and shall be sound, dense, hard and durable rock capable of being spread and compacted as specified. Individual pieces are to be clean and angular. It shall be the Contractor's responsibility to excavate material from rock cuts, whether by blasting or other means, so that all excavated materials are of suitable size.

When suitable materials of widely divergent characteristics are drawn from different sources, such materials may, if approved, be mixed to meet the embankment requirements. Rock and other materials shall be incorporated in such manner as to avoid segregation and an accumulation of boulders, etc., at the toe of embankment slopes.

Logs, trees, stumps, weeds, heavy grass, vegetable matter or other undesirable and non compatible materials shall not be placed in embankments.

Rocks larger than 100 mm in any dimension shall not be used as fill material in areas where piling works are to be carried out.

Any materials which are classified as rock have to be visually inspected by the Government Center for Testing and Laboratories (GCTL) in order to confirm the given classification.

201.01.2 Unsuitable Materials

Unsuitable materials shall include:

- Materials that do not comply with the requirements for suitable materials as specified under Clause 201.01.1 above.
- Materials incapable of being compacted to the specified density using ordinary compaction methods at optimum moisture content for the equipment being used for compaction.
- Material too wet to be compacted and circumstances prevent suitable in-place drying prior to incorporation into the work.
- Materials which are otherwise unsuitable for use in or under the embankment.
- Materials which contain rubbish, debris, wood, plastic, etc.

The samples of material considered unsuitable for filling shall be collected and checked by the Government

Center for Testing and Laboratories (GCTL).

201.02 WATER

The use of fresh water and sea-water in addition to brackish water will be permitted for all Earthwork operations unless specifically stated to the contrary.

Potable water shall be used for compaction of backfill material within the area paid for as structural excavation or within an area of one meter from all surfaces of the structure, whichever is the lesser.

202 - MAIN MACHINERY UTILISED IN EARTHWORK CONSTRUCTION

202.01 GENERAL

The machinery and tools utilized in carrying out earthworks and other related works for the road construction and in maintenance of the work shall be in good working condition, and the Contractor shall maintain them in such condition for the whole duration of the works.

The Engineer shall approve the machinery and tools prior to the commencement of work and the Contractor shall supply an adequate number of tools and machinery as deemed necessary for the proper execution of the work with due speed and precision and shall by no means be limited to the types of equipment or recommended minimum number stipulated in the Contract Documents, which shall be used for guidance purposes only. The Contractor shall provide the Engineer with copies of catalogues, technical data, charts etc., in English language, of the machinery to be utilized on Site prior to the commencement of the work.

Notwithstanding the minimum number of each item required by these Specifications, the Tenderer shall include with his tender in the Plant and Equipment Register Form, Volume I of the Contract Documents, the actual number and type of machine or equipment which he intends to provide on Site.

The Contract is awarded on the understanding that the actual numbers of machines and other plant will not be reduced below the numbers shown in the Contract except after specific written approval from the Engineer.

The Engineer reserves the right to request the Contractor to provide additional Plant and Equipment specified herein and indicated in the Register Form, Volume 1 of the Contract Documents, for proper and timely execution of the Works.

Prior to commencing construction of the permanent works, unless otherwise agreed with the Engineer, the Contractor shall carry out compaction trials for each aspect of the earthworks to establish an approved rolling/compaction procedure, which shall then be used as a minimum requirement for the permanent works unless otherwise directed or agreed by the Engineer.

The compaction trials shall involve all procedures specified for the permanent works including testing and any equipment, processes or procedures as proposed by the Contractor which are not included as a part of these specifications. Construction of the permanent works shall not commence until a rolling/compaction procedure has been approved in writing by the Engineer. Such approval shall in no way relieve the Contractor of his responsibilities and obligations stipulated in the Contract.

The compaction trials shall not be measured or paid for separately but shall be considered an incidental obligation of the Contractor under this Section of the Specifications.

202.02 ROTARY CULTIVATORS

They shall have axles rotated by a powerful motor and be equipped with metal teeth or plates. They shall be designed in such a way as to ensure proper pulverization and mixing of soil. They must be equipped with apparatus to lift and lower the axles so as to be always to the required depth.

202.03 WATER SPRINKLERS

They shall be borne by trucks with pneumatic tyres and shall be equipped with a pressure pump and water sprinkling distribution equipment. The pump shall be powered in such a manner that the pump pressure will remain uniform regardless of variations in truck speed. The distributors shall be so designed as to allow

sprinkling and adding of water to the soil uniformly and in controlled quantities and shall be equipped with an approved gauge to control the quantity of water added during operation. Special spray bar attachments shall be provided and used in order to sprinkle water on sloped sections.

202.04 BULLDOZERS

They may be tracked and/or pneumatic-tyred vehicles and shall be equipped with a blade for earth moving and leveling. Ripper attachment shall be provided when necessary. The blade level shall be hydraulically controlled to raise or lower it so that the work surface can be formed and adjusted as required.

202.05 MOTOR GRADERS

They should be pneumatic-tyred and shall be equipped such that it is possible to lift, lower and adjust the angle of the blade as required to control the grading operation and to perform grading without making any undulations

202.06 SHOVEL TRACTORS

They shall be tractors equipped with a shovel for earth hauling or moving and may be either on tracks or on pneumatic tyres. The shovel must be hydraulically controlled to raise and lower it as required.

202.07 ROLLERS

Rolling equipment shall consist of pneumatic-tyred rollers and steel wheeled rollers as described below:

202.07.01 Pneumatic-Tyred Rollers

They shall be equipped with tyres of equal size and diameter which shall be uniformly inflated so that the air pressure of the tyres shall not vary by more than 0.35 kg/cm^2, one from another. The wheels shall be spaced so that one pass will accomplish one complete coverage equal to the rolling width of the machine. There shall be a minimum of 6 mm (1/4 inch) overlap of the tracking wheels.

Self-propelled pneumatic-tyred rollers shall comply with the following ratings:

- Minimum weight without ballast 9000 kg
- Minimum weight with ballast 18000 kg
- Minimum size of tyres 10 x 20 – 14 ply or 13 x 25 – 18 ply
- Tyre Inflation pressure 3.9 – 8.4 kg/cm2
- Minimum number of tyres 7
- Minimum wheel load 1300 kg
- Minimum wheel load with full ballast 2500 kg

202.07.02 Steel Wheeled Rollers

They shall be of four types, three-wheeled, tandem, vibratory steel tandem and single drum vibratory steel rollers.

Three-Wheeled Rollers

Shall be self-propelled and equipped with a reversing clutch, a differential drive and with adjustable scrapers to keep the wheel surface clean. They shall comply with the following ratings:

- Manufacturer rating, kg 15000
- Minimum diameter, rear wheel, meters 1.83
- Minimum width, rear wheel, meters 0.56
- Minimum compression per mm width of
- rear wheel, kg 8.32
- Minimum lap, each side, front and rear
- wheel, meters 0.86
- Maximum rolling speed, km/h 3.2

Tandem Rollers

Shall be self-propelled equipped with reversing clutches, sprinkling system having a storage tank of not less

than 320 litres (70 gallons) to spray front and rear rolls, and adjustable spring scrapers fitted to the driving and steering roll to scrape in both directions. They shall comply with the following ratings:

- Manufacturer rating, kg (unballasted) 7000 – 8000
- Manufacturer rating, kg (ballasted) 10000 - 12000
- Minimum diameter, driving roll, meters 1.32
- Minimum diameter, steering roll, meters 1.02
- Minimum rolling width, meters 1.27
- Minimum compression per mm width of driving roll, kg 3.49
- Maximum driving speed, km/h 3.20
- Minimum wheel base, meters 3.05

Vibratory Steel Tandem Rollers

Vibratory steel tandem rollers shall have the requirements of the foregoing steel tandem rollers with a static weight of at least 5000 kg and a vibrating frequency between 1500 and 2000 cycles per minute.

Single Drum Vibratory Steel Rollers

They shall be double axle, self-propelled Units with the rear axle equipped with pneumatic flotation wheels. They shall have vibrating frequency capabilities between 1500 and 2000 cycles per minute.

202.07.03 Portable Vibratory Compaction Rollers

They shall be double axle tandem single-drum self-propelled equipped with a vibrating element delivering an impact of not less than 1590 kg at a frequency of about 5000 cycles per minute. The roller shall be easily maneuverable, of an adequate width and suitable for rolling ditches and their side slopes having a grade of up to 3:1.

202.07.04 Mechanical Hand Compactors

Hand compactors, shall be capable of delivering an impact of between 750 to 1500 kilograms.

203 - METHOD OF EXECUTION OF WORKS

203.01 BENCH MARKS AND MONUMENTS

203.01.1 General

Before commencing the works the Contractor shall obtain from the Engineer all information pertaining to project related bench marks and monuments bearing local grid coordinates. The Contractor shall be responsible for maintenance of these bench marks and monuments throughout the Contract period. He shall also establish supplementary bench marks and monuments as may be necessary or as directed by the Engineer. All pertinent levels, lines and locations must be checked and verified by the Contractor before commencing the Works.

At the time of Substantial Completion of the whole of the works, a schedule and plan drawing(s) of all remaining project related and supplementary bench marks and monuments shall be prepared and transmitted to the Engineer. Those bench marks and monuments determined by the Engineer as needing to be made more permanent shall be made into permanent bench marks and monuments in accordance with the details shown in the Drawings and described below.

All project related bench marks and monuments made permanent as above will be shown on the as-built plans, including the co-ordinates and level information for each.

203.01.2 Description

This work shall consist of all of the above, including placement of permanent Portland cement concrete bench marks and monuments, in reasonably close conformance with the Specifications and with the dimensions and details shown in the Drawings, and at the locations directed by the Engineer.

203.01.3 Materials

The Contractor may request the Engineer's approval for concrete monuments, markers and posts supplied by an established commercial manufacturer, whose capability of producing specification monuments has been well established by both testing and performance. Written approval shall be obtained prior to installation of the units on the project.

203.01.4 Construction Requirements

Fabrication and installation of bench marks and monuments shall be as shown on the Drawings or in the Specifications and shall include attaching warning reflectors and painting if required. Each bench mark and monument shall be set accurately at the required location and elevation and in such manner as to ensure its being held firmly in place.

203.02 SETTING OUT

After the Contractor is handed the Contract Drawings and after taking over all the existing permanent bench marks, he shall carry out at his own responsibility and expense the setting out of the work, definition of levels and center lines, axes and slopes, all in accordance with the Drawings.

The Contractor shall be responsible for the true and proper setting out of the work in relation to original points, lines and levels of references given in the Drawings and for the accuracy of the positions, levels, dimensions and alignment of all parts of the work, and for any delay or loss resulting from errors made in completing the setting out of the work. The Contractor shall protect, preserve and be responsible for all existing bench marks, pegs and boundary marks and shall keep them in place or replace them when necessary either in their positions or in some other approved positions.

Setting out shall be approved by the Engineer and before commencing the works, but such approval shall in no way relieve the Contractor of his responsibility for the correct execution of the work.

203.03 SURVEY OF EXISTING GROUND LEVELS

The Engineer will survey cross-sections of the Site prior to the commencement of work in any section.

The Contractor shall include in his Critical Path Program, the date by which survey work should be completed in each section of the Site. No work may commence in any section prior to the program date without the written approval of the Engineer.

Sections will be prepared at such intervals as are necessary to give a representative record of existing conditions and in no case will the intervals exceed 50 meters.

The Engineer will give the Contractor 48 hours notice of his intention to carry out survey work in any particular section of the Site and the Contractor may nominate a representative to be present to observe the survey. If, having been given such notice, the Contractor fails to appoint a representative or if the representative should fail to be present during the survey work, the Engineer shall proceed with the survey which shall be deemed to have been prepared in the presence of the Contractor.

The Engineer will prepare Drawings showing the various cross-sections obtained from the above survey. The original of the Drawings shall be signed by the Engineer and the Contractor as an agreed record of the existing ground levels. A copy transparency of each original Drawing will then be given to the Contractor. These Drawings shall be deemed to be revised Contract Drawings replacing the original Contract Drawings and shall be used as the basis for re-measurement of the Works as specified.

203.04 CLEARING AND GRUBBING

The Contractor shall excavate and/or remove and cart away surface material such as debris, windblown sand, vegetation and any other unsuitable material in the areas and to a maximum thickness of 200 mm unless instructed otherwise by the Engineer. Clearing and grubbing shall be restricted to removal of surface material and debris within the limits of the actual road width (including the toes of fill and cut slopes and an additional 5m wide band from both sides), easement areas and borrow pits (except items designated to remain or which are to be removed at a later stage of the Works) and shall not include the excavation of natural ground unless directed by the Engineer. The corrected ground surface following the clearing and grubbing will be adopted in

the remaining Clauses for measurement, payment and strength.

The material shall be loaded and carted away to a dumping area to be approved by the Municipality and/or the Environmental Public Authority if the material proved to be toxic or contain toxic material, which will be within a 60 km radius from the site of work. The Contractor shall be responsible for obtaining the location of the dumping area as well as the necessary permits and approvals from the relevant authorities.

All surface objects and trees, stumps, roots and other protruding obstructions, not designated on the Drawings to remain, shall be cleared and/or grubbed as required except as provided below:

- In areas outside of the grading limits of cut and embankment areas, stumps and non-perishable solid objects shall be cut off not less than 500 mm below finished ground level.
- In areas to be rounded at the top of cut slopes, stumps shall be cut off flush with or below the surface of the final slope line.
- Grubbing of pits, channel changes and ditches will be required only to the depth necessitated by the proposed excavation within such areas.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted in accordance with Clause 203.08 of these Specifications. Small holes that are inaccessible to compaction / tamping equipment shall be filled and tamped manually using a steel rod with a 10-15cm diameter steel disc attached to its end.

Removal of structures and similar obstructions and removal of utilities shall be as specified in Clause 207 "Removal of existing pavements and obstructions".

203.05 ROADWAY EXCAVATION

203.05.1 Utilization of Excavated Materials

All materials removed from the excavation shall be used in the formation of the embankment, subgrade, shoulder, dykes, and at such other places as directed, as long as it complies with the requirements of suitable fill materials outlined in Clause 201.1 of these specifications, otherwise it will be declared unsuitable and ordered to be wasted by the Engineer.

No excavation material shall be wasted without written permission from the Engineer.

Excavated rock which is not immediately suitable for incorporation in the works can either be broken down to acceptable sizes or wasted at Contractor's own expense. If such material is wasted or used in concrete or any other works, the Contractor will replace it by borrow excavation for embankment at no extra cost to the Employer.

Suitable topsoil material if specified shall be stockpiled during excavation operations and shall subsequently be spread and compacted on embankment slopes and elsewhere as directed, to facilitate re-growth of vegetation.

If the Contractor chooses to treat suitable excavated material as waste or put it to other uses, and replace it by borrow excavation for embankment areas, this shall be undertaken at no extra cost to the Employer.

203.05.2 Excavation of Unsuitable Material

If during the progress of the work the soil encountered has characteristics, as determined by tests conducted under the direction of the Engineer, that render it unsuitable for incorporation in the road embankment (considering the criteria specified under Clause 201.01.2 of these Specifications), the Contractor shall excavate and remove such unsuitable material to the extent directed by the Engineer.

The resulting excavated unsuitable material shall be removed and carted away to the approved dumping area referred to in Clause 203.04 of these Specifications or shall be deposited elsewhere on Site as directed or approved by the Engineer.

The Contractor shall replace this unsuitable material using approved suitable material that shall be constructed in layers not exceeding 150 mm compacted thickness to the density specified, as provided for in Clause 203.08 of these Specifications.

Where excavation to finished grades and cross sections exposes unsuitable material in the subgrade, slopes or

ditch inverts, etc the Engineer may require the Contractor to remove the unsuitable material and backfill the excavated areas using approved suitable material. The Contractor shall conduct his operations in such a way that necessary cross section measurements are taken before such backfill is placed.

When the Contractor is directed to excavate unsuitable material below the surface of the original ground in fill areas, other than that required for clearing and grubbing, the depth to which unsuitable material shall be removed will be determined by the Engineer. The Contractor shall schedule the excavation so that cross sections are taken before and after material has been removed.

Materials outside the right of way (Contract limits) or ditch slopes which, in the opinion of the Engineer, are potentially unstable and liable to slide or encroach into the right of way or into the ditches, shall be excavated and disposed of as specified for unsuitable material, unless it is approved for use as embankment fill.

203.05.3 Excavating High Level Areas

The Contractor shall excavate high level areas in all materials including rock for the full width of the road construction (within limits of Contract inclusive), and shall finish the roadbed true to lines, grades and cross sections as shown on the Drawings. The Engineer will periodically check all or any part of the Works to determine conformance to the correct lines, grades and elevations.

These works shall also include any necessary excavations outside the limits of Contract ordered by the Engineer to safeguard and protect the Works. These may include diversion of existing wadi channels; excavation of materials obstructing or impairing the flow along stream channels; and excavation of unstable materials which may slide or encroach into ditches or onto the right of way.

Slopes, except in massive rock or other material which require special treatment, shall be trimmed to slopes not steeper than the specified slope angles and rounded at top and bottom to a smooth profile to blend in with the adjacent terrain. Material shall not be loosened beyond the specified slope lines. High cut areas shall continuously be monitored by an Engineering Geologist or a Geotechnical engineer.

In cuts where earth overlays a rock formation, slopes shall be benched in an approved manner.

In case rock or soil excavations revealed that the adopted cut slopes are not suitable and in case failures occurred during or after completion of the excavation works and the Contractor is still on Site (i.e. before the issuance of the Taking Over Certificate), then the Engineer shall request the Contractor to re-excavate according to the newly established cut slopes and he will be paid for the additional quantities using the same rates of the Contract. However, in this case, the Contractor can submit his proposal for any other alternative solution he may find suitable for the stability of the cut slopes, to the Engineer's appraisal and final decision.

The subgrade preparation and construction (including replacement of any unsuitable soil) shall be as specified under Clause 206.03 of these Specifications.

Suitable and approved excavated material from any part of the site shall be hauled and used for filling in any other section of the Site in accordance with these Specifications. The Contractor shall at his own responsibility and expense store such material when necessary, until the need arises for its use in filling as required by the phases of construction, or as directed by the Engineer.

Where the amount of suitable material excavated from high level area exceeds the amount of fill required for the Project, the Contractor shall dispose of the surplus material at locations designated by the Engineer/Municipality within a 60 km radius from the site of the work. The Contractor shall off-load, spread, level, water and carry out other related operations at the disposal site as directed by the Engineer/Municipality.

203.05.4 Rock Excavation

Rock shall be defined as any naturally formed solid matter encountered in excavation having a crushing strength of not less than 70 kg/cm^2 when dry and not less than 40 kg/cm^2 after submergence in water for 24 hours (twenty four hours). This shall be determined on samples of 100 mm x 100 mm cubes obtained from said material. (Equivalent cores in lieu of above cubes may be considered for testing at the discretion of the Engineer). Individual masses of solid material found in excavation and weighing less than 500 kg shall not be considered as rock. Any artificially formed solid matter such as blockwork or concrete shall not be considered as rock.

The Contractor, at his own responsibility and expense, shall supply any equipment and labour necessary to obtain samples suitable for testing by the Engineer. The Engineer shall determine the location and quantity of samples necessary to determine the extent of the rock. These samples shall be taken in the presence of the Engineer.

In the event that the tests prove that the material is rock, the Engineer shall determine the extent of such material and shall instruct the Contractor accordingly.

The use of explosives shall be governed by Clause 102.08 of Section 1 (General) of these Specifications.

In case permission to use explosives is not granted, claims for any additional costs or delays whatsoever shall not be considered.

After it has been established that the excavated material is rock and after the area where such rock exists has been defined, the Contractor shall incorporate the rock in the embankment.

When excavated material contains more than 25% of rock larger than 150 mm in greatest diameter and cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down the pieces resulting from excavation methods, such materials may be placed on the embankment in layers not exceeding in thickness the approximate average size of the larger rocks, but not greater than 500 mm.

Even though the thickness of layers is limited as provided above, the placing of individual rocks and boulders greater than 500 mm in diameter will be permitted provided that when placed, they do not exceed 1 meter in height and provided they are carefully distributed, with the interstices filled with finer material to form a dense and compact mass.

Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of earth. Lifts of material containing more than 25% of rock larger than 5 mm in greatest dimension shall not be constructed above an elevation 300 mm below the top of finished subgrade. The balance of the embankment shall be composed of suitable material smoothed and placed in layers not exceeding 150 mm in loose thickness and compacted as specified for embankments. The top 300 mm shall be in accordance with Clause 206 of these Specifications.

203.05.5 Manual Excavation

The Contractor shall excavate manually in the vicinity of all services, structures, and any other areas, and if necessary uncover them, all as directed by the Engineer. Excavations shall be carried out in the presence of the Engineer, taking all precautions to prevent damages to services, properties and persons, and any damage resulting from the negligence of the Contractor, his agents, or his employees, shall be repaired at the Contractor's expense. The Contractor shall have no right to claim any expenses or delays resulting from his failure to abide by the Engineer's directions. No separate payment shall be made for manual excavation, which shall be included in the rate for excavation works.

203.06 FILLING LOW LEVEL AREAS / EMBANKMENT FOR WIDENING EXISTING EMBANKMENT

203.06.1 Description

These works shall consist of constructing roadway embankments, including preparation of the areas upon which they are to be placed; placing and compacting approved suitable material (as specified under Clause 201.01.1 of these Specifications) within areas where unsuitable material has been removed; and placing and compacting approved embankment material in holes, pits and other depressions within the constructed area, all in accordance with the lines, grades and cross sections shown on the Drawings.

203.06.2 Foundation preparation

If the original surface upon which embankment is to be placed is an existing pavement, the surface shall be ploughed, scarified, or otherwise broken up regardless of the height of the embankment to be placed thereon.

Clearing and grubbing, and removal of tree stumps, shall be undertaken. The degree of compaction for the area to be cleared shall then be determined. The top 150 mm of the surface on which the embankment is to be placed shall be scarified to a depth of 150 mm for the full width of the embankment except where the material is

classified as rock. The scarified material shall be watered as required, thoroughly mixed, brought to a uniform moisture content within the specified range, shaped and compacted to the density specified for the embankment. Hard and smooth surfaces are to be roughened before filling is placed.

Where embankment is to be placed over topsoil containing unsuitable organic material failing to meet the requirements of Table 201.01.1 the ground shall be stripped off to a depth of 200mm and the cleared surface shall be scarified to a minimum depth of 200mm or as directed by the Engineer, brought to a uniform moisture content within the specified range, and compacted to the density specified for the embankment..

Where embankment is to be placed and compacted on hillsides or where new embankment is to be compacted against existing embankments or where embankment is built part width at a time, the slopes steeper than 3:1 (H:V) when measured at right angles to the road centerline shall be continuously benched as the embankment is brought up in layers. Benching shall be of sufficient width to permit operation of spreading and compaction equipment, and in any case not less than 2 m wide except where insufficient width is available between existing and new embankments. Each horizontal cut shall begin at the intersection of the original ground and the vertical sides of the previous cuts. The vertical face of each bench shall not be less than 1 m in height and not exceed 2 m.

Where embankment is to be placed and compacted on wadi slopes, the entire slope area shall be graded and trimmed to remove any vertical faces and overhangs. The final graded slope shall not be steeper than 1.5:1 (H:V). The slope shall then be continuously benched as the embankment is brought up in layers, all as described above for embankment on hillsides.

Rockfill shall not be placed on any slopes steeper than 1:1. All slopes steeper than 1:1 shall therefore be re-graded to a slope of 1:1 or milder and all vertical faces and overhangs removed.

203.06.3 Embankment construction

Prior to placing embankment material on any area, it shall have been cleared and grubbed as specified in Clause 203.04 of these Specifications, and the foundation prepared as specified in Clause 203.06.2 of these Specifications.

Equipment used for foundation preparation and for placing, spreading and compacting embankment materials shall be of approved types and furnished in sufficient numbers for the purposes intended. Provision and use of such equipment shall conform with the relevant requirements and with the Contractor's approved Program of Work.

Draglines shall not be used to construct embankment unless approval is given and only when special procedures are adopted to keep the layers uniform and the embankment properly graded and well-drained at all times.

Surfaces of embankment layers shall be kept properly shaped and drained at all times. The Contractor shall utilize a sufficient number of motor graders or tractors to level and maintain the surface of each layer of embankment during all placing and compacting operations.

Rockfill shall not be used in the top 300 mm of the embankment below the subgrade. If found necessary and if approved by the Engineer, water may be added as required to achieve maximum compaction.

Whenever feasible, trucks, scrapers, tractors, loaders and other heavy hauling equipment shall be routed over the embankment in such a manner as will contribute effectively to compaction of the fill material.

Where an embankment is to be constructed over an area previously occupied by a building basement, cellar, irrigation canal, well, any previous excavation, or adjacent to structures, and where the proper use of normal compaction equipment is not practicable, the embankment shall be constructed and compacted in accordance with the backfilling requirements of Clause 208 - " Structure Excavation and Backfilling" of these Specifications until the use of normal compaction equipment is practicable. Layers shall not exceed 200 mm thickness (before compaction) and shall be compacted to the degree of compaction specified for the embankment.

Where an existing embankment is being widened, the existing embankment slope shall be trimmed and compacted to form a step prior to placing and compacting each layer of new embankment material unless otherwise directed by the Engineer to suit particular circumstances.

The Contractor shall not proceed with filling and compacting any subsequent layer prior to securing the approval of the Engineer for the previous layer.

Each embankment layer shall be tested and approved prior to placing the following layer in accordance with Clause 204 “Testing Requirements” of these Specifications.

After securing the approval of the Engineer, the Contractor shall slightly scarify the surface of the approved layer to a depth between 5 and 10 mm to ensure a good bond with the subsequent layer.

The Engineer may at any time order suspension of delivery of materials to the embankment Sites until previously delivered materials have been properly placed and preceding layers are leveled and uniformly compacted to the specified density.

Unacceptable material placed in any embankment shall be removed and disposed of by the Contractor at his own expense, immediately after receiving the Engineer’s instructions in this regard. Any expected delay with the removal of such material shall be coordinated and agreed with the Engineer.

The Contractor shall be responsible for the stability of all embankments and shall replace all embankment sections which, in the opinion of the Engineer, have been damaged or displaced due to carelessness or neglect on the part of the Contractor, or due to normally occurring natural causes, such as storms, and not attributable to the unavoidable movement of the natural ground upon which the embankment is constructed.

All embankment side slopes shall be neatly finished true to the lines and not steeper than the slope angles as shown on the Drawings. The bottom (toe) of side slopes shall be graded to a well rounded, smooth profile to blend in with the adjacent terrain.

The side slopes of rockfill embankments shall be thoroughly blanketed with A-1, A-2-4 material, and compacted to the satisfaction of the Engineer

The Engineer may permit the Contractor to utilize suitable surplus material at his own expense to widen embankments or flatten slopes, etc within the right-of-way. Surplus material used in such manner shall be compacted to 90 % of maximum density, but this shall not be measured for payment. When widening embankments, the Contractor shall bear the cost of modifying the culverts and any protection work necessary.

Potable or Sea Water can be used for all embankment construction works, except that only potable water shall be used for compaction of fill material within 1m from all surfaces of structures.

All material for a depth of 300 mm below the subgrade level must meet the requirements of Clause 206 of these Specifications.

Embankments that consist of rock-soil material with sufficient soil to make rolling feasible shall be placed and compacted in an approved manner and to the required degree of compaction. Water shall be added as and when directed to assist in the compaction of such materials.

In the case of embankments which are to be formed of approved rock-soil material containing an appreciable quantity (normally not exceeding 30% greater than 80mm) of rock fragments and which cannot be placed in layers of the thickness prescribed without crushing, pulverizing, or otherwise breaking down the fragments, the embankment may be constructed in layers not exceeding in thickness twice the average size of the largest rock fragments and in any case not exceeding 600 mm (before compaction).

Rockfill materials shall be placed in such a manner that the larger rocks are well distributed and the voids are filled to the maximum practical extent by smaller particles, each layer shall be bladed into a neat and homogeneous mass prior to compaction. Any rocks found protruding from the leveled surface shall be removed and replaced by smaller particles. Initial breakdown compaction shall be performed with heavy bulldozers. The top level of each layer must be surveyed before and after compaction and approved by the Engineer before the next layer is placed. Oversize rock pieces (i.e. exceeding the maximum particle size defined in Clause 201.01.1 of these Specifications by not more than 10%) may be used in high rockfill embankments to a level 3 meters below subgrade.

Rockfill shall not be used within 5m of a structural element (next to bridge abutments footings, etc). In some specific cases, rock fragments not exceeding 75mm particle size can be used next to structural elements, but after obtaining the Engineer’s approval on the location and extent of the work.

Rockfill shall not be used within 600 mm of top and bottom of Box and Pipe Culverts. Subgrade material shall be used in these areas up to width excavated for structures.

203.06.4 Trial Embankment Construction

If shown on the Drawings, or if required by the Engineer, a trial embankment shall be constructed. The trial section shall be at least 2 lanes wide by 100 m long at approved locations at or adjacent to the Site. Compaction and other equipment used shall be as specified and listed in the Contractor's Equipment Schedule and the additional equipment requested by the Engineer and approved Program of work.

The initial sections of rock embankment shall serve as the trial sections for rock fill, in order to establish the optimum degrees of consolidation for the different layer thickness. This shall be obtained by compaction trials correlating number of passes of the roller with settlement of the layer, or by different approved methods. The maximum permitted layer thickness for rock fill shall be 200mm.

203.07 BORROW PITS (ADDITIONAL FILL)

203.07.1 Description

If the surplus suitable material obtained from excavations is less than the quantities required for filling, or if the Contractor chooses to excavate suitable material and put it to other uses so that the remaining quantity is insufficient, the Contractor shall supply suitable filling material from borrow pits, channels and designated borrow areas, provided they are approved by the responsible Governmental Authorities of Kuwait.

If shown on the Drawings, areas could be determined as available for the Contractor to obtain borrow material for use in the construction of the works. It is the Contractor’s responsibility to satisfy himself that there is sufficient borrow material of suitable types, if and when required, to meet the Specification requirements. The Contractor may select to use alternative sources of borrow material.

It shall be the Contractor’s responsibility to obtain all permits or permission and make any payments that may be required in acquiring the rights to borrow material whether the Contractor uses the areas shown on the Drawings or elects to use alternative areas.

These works shall consist of excavating suitable material from borrow pits, channels and designated borrow areas and hauling to locations of embankments or to stockpiles, all as and where shown on the Drawings, or as approved by the Engineer. Any delays or losses incurred will be the sole responsibility of the Contractor.

The Contractor shall obtain and supply to the Engineer’s representative samples from the borrow pits he intends to use. The Engineer will be afforded the opportunity to be present during the sampling operations. The Engineer will carry out the necessary laboratory (and, if required, field) testing to establish the suitability of the material for filling work and will advise the Contractor whether such material is acceptable and whether the borrow pit is an approved source of borrow material.

203.07.2 Location of Borrow Pits

Generally, the borrow pits shall not be located within 50 m from the toe of embankment slope or top of cut or formed slope, unless otherwise approved by the Engineer.

In no case shall borrow pit be located within 200 m downstream of a drainage structure without the written approval of the Engineer. Unauthorized borrow pits shall be backfilled and compacted, as directed by the Engineer, at the Contractor's expense.

It shall be the Contractor’s responsibility to obtain all permits or permission and make any payments that may be required in acquiring the rights to borrow material whether the Contractor uses the areas shown on the Drawings or elects to use alternative areas.

In each case where a borrow pit is proposed within privately-owned property, the Contractor shall secure the consent of the landowner in writing, if necessary, and at his own expense, pay for the use of the material and land.

The Contractor shall be responsible for any claims for compensation or complaints arising out of borrow pit operations and shall indemnify and keep indemnified the Employer against all such claims.

The Contractor shall be responsible for the stability of the side slopes of borrow pits and channels at all times, until the pit or channel is abandoned.

Details of the Contractor's proposed haul routes and traffic arrangements in relation to borrow pit operations shall be submitted for approval before any borrow excavation commences. Refer to Section 1 (General) of these Specifications for restriction on the use of certain roads by heavy vehicles during certain hours of the day/night.

Overburden and any unsuitable top layers within each borrow pit shall be completely removed and stockpiled in the vicinity, ready for re-use in the reinstatement of the pit prior to its abandonment.

Prior to abandonment of any borrow pit or borrow area, the Contractor shall spread and level the original overburden over the exposed surfaces and clean up, grade and contour the pit or area and the adjoining properties occupied during execution of borrow operations, whether Government, or privately-owned, all to the satisfaction of the Engineer and relevant Authorities.

203.07.3 Borrow Material

Borrow material shall be approved as meeting the requirements for the particular embankment, backfill or other use for which the material is intended.

The Contractor shall submit representative samples of materials from each of the proposed borrow pits or borrow areas. A minimum of three sets of tests shall be required from each borrow area for each type of material. No borrow material shall be brought to the site or used in the Works before its approval.

The Engineer will periodically require follow-up testing of borrow materials to verify that no change in quality has occurred since the original approval. Should such material fail to meet the requirements of these Specifications, approval to the use of the importation from the borrow pits will be withdrawn and the Contractor shall immediately cease importation from the borrow pits until such time as the Engineer may approve alternative sources of material from within the same borrow pits based on sampling and testing as specified above.

The Engineer will decide whether the material already imported from the concerned borrow pits can remain as placed on the site, or whether the Contractor shall remove and replace the said material at his own expense.

203.08 COMPACTION FOR SOIL AND GRANULAR MATERIALS

The Contractor shall carry out the required compaction specified after grading and leveling the surface to be compacted. In areas to be filled, compaction shall include adding necessary soil, water etc., and compacting the first layer in addition to subsequent layers up to the proposed levels. In areas already excavated down to the required level, compaction shall include adding the necessary water, etc. and compacting the surface, in accordance with the procedure outlined herein after.

The procedure outlined below shall not relieve the Contractor of his duties to determine the most suitable procedure, all subject to the approval of the Engineer.

a. After carrying out the grading, leveling, scarifying, pulverizing etc., of the soil layer to be compacted as per Specifications, the Contractor shall add the necessary amount of water to permeate the pulverized soil in the quantity required.

b. The soil shall then be thoroughly turned over after each addition of water so as to achieve a homogeneous moisture content in the whole thickness of the layer.

c. Before compacting, samples of the pulverized soil shall be tested using “Speedy Moisture Device” or similar instrument to establish the moisture content. If the moisture content is not within $\pm$2% of the optimum Moisture Content as determined by AASHTO T180, the area represented by this sample shall be scarificed and aerated or water added until the moisture content is within ±2% of Optimum Moisture Content. The soil shall then be primarily leveled in order to commence earth compaction.

d. After primary leveling referred to above, compaction shall be commenced by means of approved rollers depending on the type of soil being compacted in order to obtain the required density.

e. Filling shall be in layers not exceeding 150mm compacted thickness.

f. Soil type material used in all embankment including roadway, medians, shoulders, sidewalks and verges shall be compacted to 95% modified maximum density as determined by AASHTO T180 for the full depth of the embankment, including the top 600 mm of the embankment material immediately below the subgrade layer.

g. Cohesionless, free draining granular materials (of 75 mm maximum size, with not more than 15% passing 0.075 mm (No. 200) sieve and a Plasticity Index PI not exceeding 20%) shall be compacted to at least 70% of relative density for the full depth of embankment. The 600 mm depth of such material immediately below the subgrade layer shall be compacted to at least 75% of relative density.

h. The rolling shall be carried out in the direction of the road axis until the soil reaches the required density. In crowned sections, rolling shall start from both edges of the road in the direction of the axis. If the road is super-elevated, rolling shall commence from the lower side and continue to the higher side. In order to compensate for the amount of water loss in evaporation during the course of compaction, additional quantities of water shall be added as required.

i. The final surface shall thereafter be leveled longitudinally and transversely by motor graders and finally rolled to achieve uniform compaction free from undulations, soft spots and depressions all in conformity with the allowable tolerances for evenness of surfaces.

j. Compaction of sloped sections of the road embankments and drainage ditches shall be carried out as here before specified with regard to pulverization of soil, addition of the necessary water, shaping, compaction to the required degree of compaction and the required design sections.

k. Prior to placing material for any subsequent layer the surface shall be slightly scarified to a depth between 5 and 10mm.

203.09 COMPACTION FOR ROCK FILL MATERIALS

To ensure proper compaction of rockfill embankments, the Contractor shall be required to conduct compaction tests such as the Plate load Bearing Test or other approved equivalent tests using equipment and materials available in order to determine the best compaction control criteria.

Rock filling shall be in layers not exceeding 200mm compacted thickness.

A Rockfill test section shall be placed on a firm surface approved by the Engineer, and the material and layer thickness shall conform to the requirements of these Specifications.

The test section shall be of sufficient dimensions to permit the establishment of at least twenty leveling points on a 5 meter (5m) square grid, and no fewer than 3 points on any one line and no point less than three meters from the edge of the layer. The arrangement of the leveling points shall be approved by the Engineer.

Compaction shall then commence with a minimum of three passes of a vibratory roller. Leveling points are then established. Short lengths of painted steel bars hammered flush with the surface of the rockfill have been found suitable for this purpose. A level reading is taken at each leveling point on top of a moveable 300 mm square flat steel plate. A hole drilled in the center of the plate will enable a visual check to be made that the plate is located centrally over the bar each time.

Further readings are taken at the leveling points after two additional passes with the roller. If the average settlement is less than half of one per cent (0.5%) of the average compacted layer thickness, or as determined by the Engineer, the rockfill compaction test is complete.

If the average settlement is more than half of one percent (0.5%), two additional passes of the roller are required and the leveling procedure repeated. If the average settlement is now less than half of one percent (0.5%), of the average compacted layer thickness the test is complete. If not, this step is then repeated.

The total number of passes of the rolling equipment necessary to obtain the required result will establish the minimum number of passes to be used on the rock embankments. The Contractor shall then use this simplified procedure, that is, the equipment, rolling pattern, and number of passes, during the construction of rock embankments. However, in no case shall the number of passes be less than five (5).

This verification procedure shall be conducted for each change of material and at least once each week during

the initial stages of construction until a reliable rolling pattern is established. The frequency verification procedure can then be reduced as approved by the Engineer.

Documentation of the rockfill compaction tests shall be maintained by the Contractor in the project records and shall be copied to the Engineer.

203.10 FILLING BETWEEN MEDIAN BARRIERS

The Contractor shall take every precaution to protect the bridge columns, lighting equipment etc., when filling between median barriers and any damage to these items arising from the filling works shall be made good at the Contractor's expense.

Unless otherwise shown on the Drawings the fill material between median barriers shall be compacted to 90% density in accordance with the Specifications. The Contractor shall agree the type of plant or equipment to be used with the Engineer prior to undertaking this work.

203.11 BORINGS

The Contractor shall perform all work required to auger or core drill boreholes or test borings in locations directed by the Engineer.

The Contractor shall not carry out such borings unless the Engineer or his representative is present.

The work shall be carried out in accordance with BS 5930 and as directed by the Engineer.

The method and the type of equipment to be used for advancing the borehole shall be submitted by the Contractor to the Engineer for approval.

The depth of the borings and the depth at which core samples shall be taken shall be as directed by the Engineer.

The casing diameter shall be such as required to facilitate removal of whatever type of solid sampling or rock coring may be required, but in no case shall the inside diameter be less than 76mm. The casing shall be driven without the use of wash water unless the Engineer specifically approves simultaneous washing and driving. Washing, spudding or drilling ahead of the casing will not be permitted. The use of drilling mud to stabilize a borehole will be permitted only if the Engineer deems it is not detrimental to pumping tests, ground water observations or other testing procedures.

Samples and rock cores immediately upon recovery shall be sealed in containers as approved by the Engineer, labeled as specified in BS 5930 and delivered to the Site Laboratory included under Section 10 (Site Laboratories) of the Specifications, or to such other location within 60 km of the source as the Engineer may direct.

Each sample or rock core shall be labeled.

Where boring is by shell and auger or rotary power auger, the records shall include the following:

a. Location of borehole (Easting and Northing coordinates)
b. Surface elevation
c. Name of driller
d. Name of Engineer supervising the work
e. Date and times of boring
f. Borehole number
g. Ground level at position of boring
h. Type of plant used and method of boring
i. Diameter of boring
j. Diameter and depths of casing
k. All water levels encountered including measurements of fluctuation of adjacent tidal waters, lakes or rivers
l. Depths at which groundwater was sealed off
m. Level at which groundwater was standing at commencement and termination of working day (where a boring is on land but is near tidal waters the level of those waters is to be recorded at intervals throughout the day)

n. Level at which water, if any, was added to borehole
o. Depths at which soil/rock samples are extracted
p. Type of sampler used for samples extraction
q. Type of sample (disturbed or undisturbed)
r. Depths of base of each stratum from ground level and a description of stratum. All soil and rock description shall be in accordance with BS 5930.
s. Records of in situ tests made and instrumentation installed
t. Time for chiselling through obstruction and weight of chisel
u. Other relevant remarks

Where boring is by rotary coring methods, the records shall include the following:

a. Location of borehole (Easting and Northing coordinates)
b. Date and times of boring
c. Borehole number
d. Ground level at position of boring
e. Type of plant used and method of operation including details of type of flushing
f. Ttype of core barrel and bit
g. Depth of hole at start and end of working day or shift as relevant depth of start and finish of each core run
h. Core diameter and changes in core size
i. State of bit
j. Time to drill each core run
k. Character and proportion of each flush return
l. Level at which groundwater was standing at commencement and termination of working day (where a boring is on land but is near tidal waters the level of those waters is to be recorded at intervals throughout the day)
m. Depths of base of each stratum from ground level and a description of strata. All soil and rock description shall be in accordance with BS 5930.
n. Total core recovery (TCR) defined as percentage of the rock recovered during a single core run, with information as to possible location of core loss
o. Rock Quality Designation (RQD) of each run; RQD is the ratio expressed as a per cent of aggregate length of core pieces over 100mm in a run divided by length of run
p. Solid core recovery defined as percentage of full diameter core recovered during a single core run
q. Fracture Index defined as the number of fractures per unit meter.
r. Details of in situ tests and instrumentation installed
s. Other relevant remarks.

The testing of all samples and rock cores will be performed according to the latest International Standards, as directed by the Engineer. The Contractor shall furnish the Engineer with all pertinent data as may be required relative to the sample so as to aid the Engineer in his testing program.

204 - TESTING REQUIREMENTS

204.01 TESTING INSPECTION AND CONTROL OF MATERIAL AND WORK

For verification of material, moisture content, compaction, thickness etc., the Engineer shall at all times have access to all portions of the works and sites. All sampling and testing of material and work shall be carried out to the relevant international standards as specified and under the direction of the Engineer.

204.01.1 Testing of Materials

Materials shall be tested in accordance with AASHTO, ASTM, BS or other approved applicable and relevant standards designated in the Specifications. The oven drying of soil samples for testing shall not be carried out at a temperature in excess of 60ºC. The oven drying of aggregate samples for testing shall not be carried out at a temperature in excess of 100ºC.

The following compaction standards shall apply to embankment materials other than predominantly rock materials. The "maximum density" of soil type materials shall be the modified maximum density determined in accordance with AASHTO T 180 (Method D). The "relative density" shall be the relative density determined in

accordance with ASTM D 4254, which identifies the state of compactness of the material with respect to its loosest and densest state. The relative density shall be the standard to which the field density is referred for comparison in the case of cohesionless, free draining granular materials.

Minimum soil tests required during the construction of subgrade and/or embankment are:

- One sample for CBR, classification (AASHTO M145), and laboratory (Moisture - density) or relative density compaction from each source prior to use. Each sample shall represent not more than 5,000 cubic meters.
- One sample for classification representing not more than 3,000 cubic meters of the material in use.

Test	**AASHTO Designation**
Sampling	T 2,
Sample Preparation	T 87
Sieve Analysis	T 27, T 11, T 88
Liquid Limit	T 89
Plastic Limit & Plasticity Index	T 90
Moisture Content	T 217
Moisture-Density Relationship	T 180
Sand Equivalent	T 176
Specific Gravity	T 100
California Bearing Ratio (C.B.R.)	T 193 (Modified for T 180 compaction)
Los Angeles	T 96
Soundness of Aggregate by use of Sodium Sulfate or Magnesium Sulfate	T 104
Classification of Soil and Soil Aggregate Mixtures for Highway Construction Purposes	M 145
Density of soil in-place	T 191, T 204, T 205

204.01.2 Testing Degree of Compaction

Testing shall be done in accordance with an AASHTO method of testing (AASHTO T-180), or other approved equivalent test or procedure designated in the Specifications.

The Engineer shall test the compaction of embankment materials in accordance with these Specifications to ensure that adequate compaction or consolidation has been achieved. All such tests shall be fully documented by the Contractor, in an approved manner.

In the case of cohesionless, free draining rock-soil materials, where maximum density tests fail to produce a well defined moisture - density relationship, the relative density test shall be used, alternatively an electronic compaction meter or any other approved test equipment shall be provided by the Contractor and used to determine the degree of compaction achieved.

To determine the degree of compaction for embankment consisting of rock fill, average differential settlement values shall also be determined from surveys of an adequate number of grid point elevations as and when directed, at the commencement of, during and after embankment construction.

For rockfill embankments, it is required to determine the modulus of soil reaction by the Plate Bearing test; this shall be undertaken using the method given in AASHTO T222.

The degree of compaction of the embankment layers shall be as specified in Clauses 203.08 and 203.09 of these Specifications for soil and rock fill materials, respectively.

The density of any layer requiring compaction shall be determined in accordance with the AASHTO standards methods at a minimum rate of one test per 100 meter run or 1000 meter square, whichever is less; however if the first time pass rate exceeds 80% the frequency may be reduced to one test per 2000 meter square, and a further reduction to one test per 4000 meter square if the first time pass rate exceeds 90%.

If a layer does not conform with the required density, additional tests may be taken to determine the limits of the failing area, after which the Contractor shall rework the area until the specified density is obtained. The

Contractor shall allow enough time in his daily work program to permit the performance and checking of the above tests, before he proceeds into any subsequent operations.

204.01.3 Strength Specifications and Testing of the Corrected Natural Ground, (after Clearing and Grubbing), Compacted Embankment and Subgrade

The corrected natural ground, embankment and subgrade shall be tested for load-bearing strength.

The test method will be a measurement of dynamic deflection using Dynaflect equipment.

The results of Dynaflect testing shall be considered a measure of conformance to specification requirements for the corrected natural ground, subgrade preparation and for compacted fill.

Dynaflect testing shall be performed on permanent works and on Type IV – Long Term detours.

In the event that Dynaflect testing of an area is not possible, the work may be accepted at the discretion of the Engineer on the basis of satisfactory density results. In such cases, however, the subsequent layer shall only be accepted on the basis of Dynaflect tests.

A. Corrected Natural Ground (after Clearing and Grubbing)

Dynaflect testing shall be performed by the Contractor under the direction of the Engineer on the corrected natural ground after the requirements of Clause 203.06 of these Specifications have been met.

B. Subgrade

Dynaflect testing shall be performed by the Contractor under the direction of the Engineer after the subgrade has met the requirements of Clause 206 “Subgrade Construction” of these Specifications and after approval by the Engineer of compaction, level and evenness but before the application of a prime coat or a pavement layer.

C. Compacted Fill

In addition to a. and b. above, Dynaflect testing shall be performed by Contractor under the direction of the Engineer on the following layers of compacted soil after the layer has met the requirements of Clause 203.08 of these Specifications.

D. Total Fill Depth Layers to be Tested

- Less than 600 mm: No additional testing
- 600 mm – 1800 mm: Every 600 mm
- More than 1800 mm: Every 900 mm

Dynaflect testing shall be performed longitudinally across the full width of the area. Testing will be at maximum intervals of 25 meters and representing a maximum width of 4 meters.

A minimum of 5 tests shall be made on every strip tested.

The Contractor shall be notified by the Engineer that the tested layer is accepted or rejected within 24 hours, excluding Fridays and Kuwait holidays, following the time the result of the Dynaflect test was made available to the Engineer.

The deflection limits for Dynaflect testing shall be as tabulated below:

	Depth of Fill mm	W1 Deflection Limits milli inches
Existing corrected natural ground or embankment	0	1.38
	150	1.38
	300	1.34
	450	1.28
	600	1.24
	750	1.22
	900	1.20
	1000 or more	1.20
Top of Subgrade (On fill depths shown)	0	1.30
	150	1.24
	300	1.20
	450	1.18
	600	1.16
	750	1.16
	900	1.14
	1000 or more	1.14

TABLE 204.01.3 - Deflection Limits for Dynaflect Testing

Where Dynaflect test results fail to meet minimum stiffness requirements, the Contractor shall rework, recompact, and if necessary, remove and replace the material as required to produce satisfactory test results. This shall be at the Contractor's expense, unless it is the existing natural ground material, after clearing and grubbing, which is shown to be unsatisfactory, in which case it shall be deemed to be unsuitable and shall be treated and measured in accordance with Clauses 203.05.2 and 205 of these Specifications.

205 - MEASUREMENT AND PAYMENT FOR ROADWAY EXCAVATION AND FILLING WORKS

205.01 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

205.01.1 Excavation and removal of unsuitable soil

Excavation and removal of unsuitable soil shall be measured by the meter cube, in place, as executed. Data relevant to such excavation and removal shall be agreed between the Engineer and Contractor at the time of excavation of the unsuitable material and shall be incorporated into the drawings prepared under Clause 203.03 of these Specifications.

Payment shall be at the rate included in the Bills of Quantities and the rate shall include for excavating, loading, carting away and dumping off excavated material as specified and for the replacement of the unsuitable material by other surplus approved excavated material and compacting all as specified. Replacement of the unsuitable material by fill from borrow pits and compacting it as specified shall be paid in accordance with Clause 205.01.5 of these Specifications unless specifically mentioned otherwise.

Measurement and payment for the excavation and removal of unsuitable soil shall apply only to that occurring 300 mm or more below top of subgrade level.

205.01.2 Excavation of Unstable Material

Excavation of Unstable Material from areas outside the right of way shall be measured by cu.m. of material excavated, hauled away and disposed of as directed, completed and accepted.

Measurements shall be of volumes computed from surveyed cross sections of original and final ground elevations. When cross sectioning is impractical in the opinion of the Engineer, approval may be given to measure volumes in the vehicles removing such excavated material.

205.01.3 Excavating high level areas

Measurement and payment for excavation in high level areas shall apply only to those areas occurring above top of subgrade level and/or finished ground level, excluding for unauthorized undercut below top of subgrade or excavations taken wider than required.

The method of measurement shall be by the meter cube calculated from the difference between existing ground levels after clearing and grubbing (corrected ground levels) and final subgrade elevations and/or finished ground levels as per the Drawings and as specified herein. This calculation shall include the volume of all suitable and unsuitable materials encountered of any nature, including silts, clays, sand, gravel, granular materials and rock, as instructed and approved by the Engineer, but exclude the volume of existing pavement, kerbs, foundations and the like as determined by the Engineer.

Where the full width of the subgrade is contained on both sides and below within a structure (e.g. trough or tunnel) then the measurement of excavation for such work shall be included in Structure Excavation (Refer to Figure 208.08.1 hereof).

Payment shall be made at the rate included in the Bills of Quantities, which rate shall include excavation, haulage and stockpiling of excavated material for filling including spreading, leveling and compacting of the suitable material in layers or the disposal of unsuitable or surplus suitable material, all in accordance with these Specifications.

The above rate shall also include shaping and compacting the roadbed, shoulder, drainage ditches, sidewalk and slopes and performing all required testing, all in accordance with the Specifications and in conformity with the Drawings.

205.01.4 Rock Excavation

Rock shall be measured by the meter cube as an extra over to the main excavation measure for each item of excavation irrespective of depth, except where the specifications state specifically that no separate payment shall be made for excavation in rock. The extra over for rock shall be measured within the same limits as apply for the main excavation measure. Payment shall be at the rate included in the Bills of Quantities, and shall include for the extra over costs of excavation, removal and hauling to approved dumping areas or incorporation in the Works as approved by the Engineer.

205.01.5 Borrow pits (additional fill)

The measurement for this work shall be in cu.m. of material excavated, hauled and used in the proper formation of embankments and backfilling where necessary, and shall be made by calculating the total required volume of fill after compaction, including filling behind and between barriers and any replacement of unsuitable material below subgrade or structure, and deducting therefrom the volume of roadway excavation less an allowance for material condemned by the Engineer as unsuitable for filling.

Payment shall be made at the rate included in the Bills of Quantities which rate shall include for but not by way of limitation, excavating, loading, hauling, off loading, spreading, watering, and compacting and for the requirements of Clause 203.07 herein including the payment of any charges made in respect of materials obtained from borrow pits. The rate shall also include shaping and compacting the roadbed, shoulder, drainage, ditches, sidewalks and slopes and performing all required testing, all in accordance with the Specifications and in conformity with the Drawings.

No extra payment shall be made for additional fill to compensate for shrinkage or settlements and the Contractor is deemed to have allowed for this in his rates.

Payment under this Clause shall also include for any necessary stock-piling and double handling of filling material and all measures to ensure that as-excavated suitable material remains in a suitable condition for incorporation in the works. Any as-excavated suitable material which, in the opinion of the Engineer, is unsuitable for incorporation in the works at the required time, shall be removed from the site and shall be replaced by suitable material from borrow pits at the Contractor’s expense.

205.01.6 Clearing and grubbing

Payment shall be as a Lump Sum Item in the Bills of Quantities. This sum shall include full compensation for

all labour, materials and equipment. The area of this work shall be that area contained within the Right of Way or Limits of Construction as shown on the Drawings. The thickness of the clearing and grubbing shall be as a minimum 200 mm unless instructed otherwise by the Engineer. No payment shall be made to the Contractor for clearing and grubbing outside these limits unless such work is authorized by the Engineer in advance.

The corrected natural ground surface following the clearing and grubbing will be adopted in the measurement and payment Clauses stated herein for excavation and filling.

205.01.7 Filling between median barriers

Measurement of the filling between the median barriers shall be by the meter cube as executed. Deductions shall be made for the volume of manholes and handholes, chambers, concrete foundations and the like. No deduction shall be made for the volume of buried cables, cable tiles, pipes and the like. Payment shall be at the rate included in the Bills of Quantities which rate shall include for the proper execution of the work including filling suitable material into the median, grading of the top as necessary, working around all fixtures within the median and all other work as directed by the Engineer.

Payment shall also include any excavation or preparation in the filling between the median barriers for the installation and laying of any ducts, electrical cables, wires and the like and subsequent backfilling and compaction.

205.01.8 Borings

Measurement for augering or core drilling boreholes shall be by the meter run. Payment shall be at the rate included in the Bills of Quantities and shall be full compensation for providing all labour, materials, tools, equipment and appurtenances and performing all work required to advance the boreholes, provide samples and rock cores and all related work as required, specified herein or directed by the Engineer.

205.01.9 Bench marks and monuments

Bench marks and monuments shall be enumerated separately.

Rates in the Bills of Quantities for this work shall be full compensation for the work specified in Clause 203.01 of these Specifications.

205.01.10 Filling low level areas / Embankment for widening existing embankment

No part of the Filling/Embankment works described under Clause 203.06 of these Specifications is a Pay Item. Original ground cross-sections taken by the Contractor prior to construction of embankment and checked and tested by the Engineer shall form the basis for computing the volume of Embankment required in the measurement of Borrow Excavation if necessary.

The volume of Embankment displaced by pipe culverts, box culverts and associated end walls shall be deducted from the measured volume of embankment. No deduction shall be made for pipes less than 500 mm in diameter and associated end walls.

Surplus materials utilized at the Contractor's option within the right of way but, beyond the cross sections shown on the Drawings, shall not be measured as part of the embankment

Embankment foundation treatment such as stripping, scarifying and re-compaction of topsoil containing unsuitable organic material, as detailed in Clause 203.06.2 of these Specifications shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract Prices for Pay Items.

No adjustments or allowances of any kind shall be made in respect of expansion or shrinkage of earthwork volumes which may occur during excavation and compaction Works.

Scarifying old pavement beds, construction of the trial embankment section if it is outside the pavement, foundation preparation, testing including furnishing and using an approved type electronic compaction meter and grid pattern consolidation surveys, and all other ancillary embankment Works shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract Prices for Pay Items.

The amount of completed and accepted work, measured as provided for above and that is subsidiary to other items, will be paid for at the unit rates for the various items in the Bills of Quantities, which rate shall be full compensation for supplying materials, transporting and placing, for labor, equipment, tools and other items necessary for the proper completion of the work.

205.02 ITEMS IN THE BILL OF QUANTITIES

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
205.1	Excavation and removal of unsuitable soil	cu.m
205.2	Excavation of Unstable Material (outside right of way)	cu.m
205.3	Excavating high level areas	cu.m
205.4	Extra Over for Rock Excavation	cu.m
205.5	Borrow pits (additional fill)	cu.m
205.6	Clearing and Grubbing	LS
205.7	Filling between median barriers	cu.m
205.8	Borings	m
205.9	Bench marks and monuments	nr

206 - SUBGRADE CONSTRUCTION

206.01 DESCRIPTION

This work shall consist of furnishing materials, constructing the subgrade layer and preparing the subgrade surface ready to receive the pavement structure and shoulders, all in accordance with these Specifications.

The subgrade layer is the 300 mm minimum depth of selected material immediately below the subgrade surface, or as defined in the Drawings or directed by the Engineer.

Wherever shallow ground water is expected under the roadway and wherever damage to the pavement layers is potential due to water impact, a suitable subsurface drainage blanket (as specified in Clause 209 of these Specifications) shall be installed under the subgrade of the roadway. Drainage Blanket is a course of washed granular material placed to cut off upward capillary flow of pore water under paved areas, where and as shown on the Drawings.

206.02 MATERIALS

Material selected for use in the top 300 mm of cut or fill areas shall be of A-1, A-2-4 or A-2-5 AASHTO classification, having a minimum 4-day soaked California Bearing Ratio (CBR) of 20% when compacted at 100% of modified proctor AASHTO test method T-180, a maximum swell of 1 percent as determined by AASHTO T193 (modified for T180 compaction), a plasticity index of less than 6% as determined by AASHTO T90 and a density of not less than 1922 kg/m^3 (120 1b/ft^3) when compacted to 100% of AASHTO test method T-180. Materials used in the construction of the top 300mm subgrade layer shall not contain more than 1% organic matter. All material shall pass 75 mm sieve and not more than 18% shall pass 0.075 mm (No. 200) sieve. Where directed by the Engineer, the Contractor shall screen the subgrade material at his own expense.

206.03 CONSTRUCTION REQUIREMENTS

206.03.1 General

Any subgrade material not conforming to these Specifications shall be excavated and replaced, and compacted to the required density as directed by the Engineer.

Once prepared, the subgrade shall be maintained in the finished condition until the first succeeding course of sub-base, base or asphalt pavement material has been placed.

In case a drainage blanket is required in the design Drawings to be installed directly underneath the subgrade, then the subgrade material should respect the filter criteria specified under Clause 209 of these Specifications.

206.03.2 Subgrade in Cut

Where the subgrade is located in rock, the subgrade shall be undercut to a depth of 200 mm by drilling or blasting as directed. No rock shall project more than 50 mm above the undercut surface elevation. The subgrade layer shall then be constructed using approved subgrade material.

Where the 300mm depth of in-situ soil are of quality and CBR at least equal to the specified subgrade material, the top 150mm immediately below the required subgrade level shall be excavated and stockpiled in an approved manner. The underlying 150mm thick layer shall be scarified and all roots, sod, vegetable and other undesirable matter and stones larger than 75mm in any dimensions shall be removed. The material shall then be brought to uniform moisture content within the specified range and compacted to 98% AASHTO T180 (Method D) maximum density. The initially excavated and stockpiled material shall then be placed on top and shall also be brought to uniform moisture content within the specified range and have a compacted thickness of 150mm with a minimum degree of compaction of 98% AASHTO T180 (Method D) maximum density. Additional subgrade material shall be added as required to make the total compacted subgrade thickness of 300mm.

Where the subgrade is on in-situ soil which is unsuitable for retention as the subgrade layer, such material immediately below the top of subgrade layer shall be sub-excavated to a depth of 300 mm, hauled away and disposed of unless approved for use as embankment fill. The subgrade layer shall then be constructed in 2 layers using approved subgrade material, as specified for subgrade in embankment. If the material below subgrade does not consist of suitable materials satisfying the requirements of top 600mm embankment below subgrade layer, it shall be excavated for further 200mm and replaced by suitable material to satisfy the requirements of the top 600mm of the embankment below subgrade layer.

The underlying natural material shall be scarified, leveled and rolled. The surface of the natural soil shall be approved by the Engineer before placement of suitable material.

206.03.3 Subgrade in Embankment

The 300 mm minimum depth of embankment immediately below top of subgrade shall consist of selected, approved subgrade material. The material shall be spread in 2 layers (150mm each) over the full width of the top of embankment, brought to a uniform moisture content within the specified range and compacted to 98% AASHTO T 180 (Method D) maximum density.

206.04 TESTING LEVELS AND EVENNESS OF SUBGRADE SURFACE

The Engineer shall test the levels and evenness of the finished subgrade surface to ascertain their conformity to the Drawings and Specifications.

The Contractor shall make available to the Engineer a four meter straight edge and a crown template of sturdy and approved design and the necessary labour to assist in the checking operations.

Requirements:

a. When tested by a four-meter straightedge placed at right angles to, or parallel to, the road centerline or when tested by a crown template placed centrally at right angles to the road centerline, the maximum gap between the road subgrade surface and the testing edge shall not be greater than 20 mm.

b. Variation in the falls to cross-sections of the road shall not exceed 0.4%, nor shall the levels of the finished surface vary by more than +10 mm or –20 mm from the required levels.

c. These tests shall be made at any point requested by the Engineer. In the event of any failure, correction of the surface shall be carried out at the Contractor’s expense to the satisfaction of the Engineer.

206.05 PROTECTION OF SUBGRADE

The Contractor shall take all precautions necessary to protect the finished and approved subgrade from damage and to continuously maintain it in a smooth, well compacted and properly drained condition until the sub-base (or base) course is constructed.

Hauling over finished subgrade shall be limited to that which is essential for construction purposes. Any equipment used for hauling over the prepared subgrade which in the opinion of the Engineer is causing undue damage to the prepared subgrade or to the underlying materials shall be removed from the work at the request

of the Engineer.

All cuts, ruts and breaks in the surface of the subgrade shall be repaired prior to placing any subsequent layer at the Contractor's expense. The Contractor shall protect the prepared subgrade from both his own and public traffic. The Contractor shall maintain the subgrade by blading and rolling as frequently as may be necessary to preserve the subgrade in a completely satisfactory condition.

Reapproval of the subgrade will be required if the overlying course is not constructed within 14 days of subgrade completion or if the subgrade layer is damaged by traffic or any other causes prior to the placement of the sub-base layer.

206.06 MEASUREMENT AND PAYMENT

206.06.1 Method of Measurement and Basis of Payment

Subgrade preparation shall be measured by the meter square in both Cut and Embankment sections, for the depths specified above under Clauses 206.03.2 and 206.03.3 of these Specifications, respectively. Payment shall be at the rates included in the Bills of Quantities, which rates shall be full compensation for providing all labour, materials and equipment for performing subgrade preparation, including subsequent protection of subgrade, as specified herein, and as directed by the Engineer.

The rate for subgrade preparation in cut shall also include for removal of 200 mm depth of rock and replacement with suitable material.

No separate measurement and payment will be made for the protection of the sub-grade. Such work shall be considered a subsidiary obligation to the items in the Bills of Quantities.

Subgrade preparation will not be measured and paid for where the subgrade is formed by a concrete structure.

206.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
206.1	Subgrade preparation in cut	sq.m
206.2	Subgrade preparation in embankment	sq.m

207 - REMOVAL OF EXISTING PAVEMENT AND OBSTRUCTIONS

207.01 GENERAL REQUIREMENTS

207.01.1 General

The Contractor shall excavate for, demolish and remove wholly or in part and dispose of all designated redundant existing pavements, fences, buildings, culverts, manholes, inlets, gulleys, pipelines etc, or any other obstructions shown on the Drawings or as directed by the Engineer.

The Contractor shall recover for storage or re-use designated materials.

The Contractor shall backfill all resultant trenches, holes pits and excavations.

The removal, and where required recovery, of redundant water, gas and sewage pipelines and fittings and of underground cables is described elsewhere in the Contract Documents.

207.01.2 Earthworks

All necessary earthworks to uncover facilities to be demolished, removed or recovered and to backfill and compact all trenches, holes, pits or excavations resultant from demolition, removal and recovery works shall be carried out in accordance with the relevant Clauses of Section 2 (Earthworks) of these specifications, except that rock excavation shall not be measured or paid for separately.

207.01.3 Demolition and Removal Works

Demolition and removal works shall be carried out mechanically or by hand as necessary in such a manner as to cause no undue damage to the public, vehicles, pavements, services, structures etc., and the Contractor shall provide temporary works for protection when necessary, where relevant in accordance with any special requirements of concerned Service Authorities or Companies. Blasting, if approved by the relevant authorities, or other operations necessary for the demolition and/or removal of facilities and which may damage new construction shall be completed prior to placing the new work, unless otherwise provided for in the Contract.

In all cases the Contractor shall be responsible for all claims resulting from damage, of any nature, caused by carelessness or negligence on the part of the Contractor, his Sub-contractor or Agents.

Demolition or removal operations for any particular facilities shall not be started until written approval is obtained from the Engineer.

207.01.4 Recovery of Materials

Where specified on the Drawings or in the Contract Documents or where directed by the Engineer, the Contractor shall recover designated materials without undue damage, carry out any required cleaning and shall deliver the materials to locations designated by the Engineer and unload and store as required or directed.

Where specified or directed such materials shall be stored on site prior to their incorporation in the new works.

Salvaged pipe culverts and other re-usable structures shall be stored at accessible approved locations on Site and shall become the property of the Employer.

207.01.5 Disposal of Debris, Sediment, Refuse and Other Unsuitable Material

Unless otherwise specified all debris, sediment, refuse and other unsuitable material resultant from demolition, removal and recovery works shall be disposed of at approved dumping areas in accordance with Clause 102.11 of Section 1 (General) of these Specifications.

207.02 REMOVAL OF EXISTING PAVEMENTS

207.02.1 General

After sections of roadway, detours and diversions are no longer needed for traffic, the existing asphalt and/or concrete pavement layers together with all kerbs, kerb base and backing, side walk paving, edging/kerb to sidewalk paving including base and backing to same and other items shall be broken out and removed unless otherwise shown on the Drawings or directed by the Engineer.

Non-asphaltic pavement, kerbs, kerb base and backing, gutters and other associated debris shall be disposed of in accordance with Clause 207.01.5 of these Specifications unless such items are designated for recovery.

The Contractor shall examine the Site and record all obstructions and utilities at the commencement of the Works.

Where shown in the Contract Documents or as directed by the Engineer side drainage ditches and excavations shall be filled and the roadway rough graded to restore approximately the original contour of the ground or to produce natural, rounded slopes. After the rough grading is completed, the area of the old road-bed shall be scarified or ploughed to mix the remaining road material thoroughly with earth and then shall be harrowed and smoothed.

The Contractor shall be responsible for supporting and protecting existing Utilities that are to remain in place for the duration of the Contract and shall provide all necessary Temporary Works in this respect. Any damage caused to Utilities and attributable to the Contractor shall be repaired at his expense.

207.02.2 Cutting Back Existing Construction

The Contractor shall cut back all existing construction in such a manner to avoid damage to the construction, which is to remain. The Contractor shall raze, remove and dispose of old pavement of different types, (i.e. down to the bottom of the base course) or as directed by the Engineer, for the portions which are within the Limit of Work. All designated material shall be removed, without causing unnecessary damage. Any damage to the

existing pavement and other work areas which are to remain shall be restored to the satisfaction of the Engineer and in accordance with the requirements of Section 4 (Asphalt Works) and Section 5 (Concrete Works) of these Specifications.

The method of cutting back all existing construction shall be as approved by the Engineer.

Cavities left by pavement removal shall be filled to the level of the surrounding ground and, if within the prism of construction, shall be compacted to the type of compaction specified in Clause 206 of these Specifications.

207.02.3 Stockpiling Uncrushed Asphalt Pavement

During the salvaging and stockpiling operations asphalt pavement containing one or more layers of sand asphalt shall be kept separate from salvaged pavement, which does not contain sand asphalt. To accomplish this, the Contractor may be required to separate the pavement longitudinally and transversely during removal.

The existing pavement designated for salvage shall be removed and stockpiled by methods, which will minimize losses and prevent its being contaminated with other materials. Especially, the Contractor shall ensure that the material is reasonably free of soil and other matter when it is stockpiled.

The removal of asphalt pavement shall be deemed to include the existing asphalt to its entire depth and any granular base or subbase material underneath it, as directed by the Engineer. Volumes shall be calculated from the actual width and length of the paved areas and the excavation depth approved by the Engineer.

207.02.4 Stockpile Sites

The location of stockpile area or areas shall be as provided in the Contract Documents or as directed by the Engineer. The designated stockpile areas shall be within a 60 km radius from any point on the work site. Unusable perishable material shall be disposed of in accordance with the applicable laws and ordinances. Non-perishable material may be disposed of off the Site, provided permission of the concerned authorities and/or the respective property owner has been obtained in writing to dump such materials on their land.

The Contractor shall inform the Engineer when he is ready to commence stockpiling operations so that the Engineer can make the necessary arrangements to receive the material at the stockpile site. If not previously protected, the Contractor shall provide a protective enclosure around the stockpile site including a locked gate for entry. The enclosure and gate shall be of materials selected by the Contractor and approved by the Engineer. Approval of the type of enclosure to be used will be based on the ability to satisfactorily provide the protection needed and on serviceability. Construction of the enclosure and gate shall be such that the stockpile site will be free draining. The enclosure and gate will remain at the stockpile site after the Contractor has completed stockpiling operations and/or removal of material from the site.

The Contractor shall assume responsibility for maintenance of the stockpile site during the time he is depositing and removing material from the stockpile.

Maintenance responsibility shall include but not be limited to furnishing equipment when needed as directed by the Engineer to spread the material and shape the stockpile as successive loads of salvaged material are delivered, ensuring by whatever means required that no unauthorized dumping is allowed and if directed by the Engineer, consolidating and reshaping of stockpile from time to time and when final operations are complete. Reshaping of the final stockpile may require the movement of the enclosure to coincide with the new stockpile size. After changes in the enclosure are made, any surplus site will be cleared and restored to the Engineers' satisfaction.

When directed by the Engineer the Contractor shall permit other contractor's access to the stockpile site to deliver or remove materials.

207.03 REMOVAL OF FENCES

Where shown on the Drawings or where directed by the Engineer, fencing shall be removed including all support posts, gates, other accessories and foundations.

The Contractor shall ensure that suitable terminal posts, etc., are provided for remaining fencing whether inside or outside the Right-of-way limits.

Unless otherwise directed all fencing, posts, gates and other accessories shall remain the property of the

Employer and shall be carefully dismantled and delivered to the Employer's Store, the location of which shall be obtained from the Engineer. The supporting posts and supports etc. shall be carefully cleaned of concrete, avoiding damage to the posts.

Foundations and sections of fencing which are designated unsuitable for recovery by the Engineer shall be disposed of at approved dumping areas and as per the Engineer's directions.

When fences and gates enclosing pasture land or farm land are to be removed, the Contractor shall notify the Engineer sufficiently in advance to permit the property owner reasonable time to construct alternative fencing or make other suitable arrangements.

207.04 DEMOLITIONS AND REMOVAL OF STRUCTURES

Unless otherwise indicated on the Drawings or directed by the Engineer, the Contractor shall demolish and remove all buildings and structures within the Right-of-Way limits together with all foundations and retaining walls, piers, partitions and columns down to a plane not less than 1 meter below the ultimate grade in the area.

All structures shall be neatly trimmed off and the reinforcement shall be cut or burned off close to the concrete and made safe; basement floor slabs shall be broken into pieces; excess debris and other foundations concrete floor slabs, sidewalks, drive-ways, signs, sheds, garages and fences etc., shall be removed and disposed of in accordance with Clause 207.01.5 of these Specifications.

Substructures shall be removed down to the elevations of the natural stream bed. Those parts outside the stream shall be removed 300 mm below natural ground surface. Where such portions of existing structures lie wholly or in part within the limits for a new structure, they shall be removed to the extent necessary to accommodate construction of the proposed structure.

Steel bridges and timber bridges, designated to be salvaged shall be dismantled without causing unnecessary damage. Steel members shall be match marked, unless this requirement is waived by the Engineer. All salvaged material shall be stored as previously specified for reuse or possession of others.

Upon receipt of notification by the Engineer, the Contractor shall take over all responsibility of the building or buildings then acquired and vacant and shall proceed with the demolition and removal thereof as specified.

The Contractor shall inspect each building he is to demolish and remove and determine for himself the work involved and the equipment and the materials required.

Blasting if permitted, or other operations necessary for removal of existing structures or other obstructions, and which may damage new construction in the vicinity, shall be completed prior to commencing the new construction. Any use of explosives shall be permitted by the appropriate security authorities and shall be approved by the Engineer. Explosive materials shall be stored and kept under the constant surveillance of the Kuwaiti Police. Any extra left over materials shall be returned to the possession of the Kuwaiti Police. During explosion works, traffic shall be suspended from the routes linking to the Site and all diversions and other arrangements are to be carried out in full coordination with the Kuwaiti Police.

The Contractor shall carry out a structural survey of all the existing buildings and structures located within the blasting influence distance. The survey shall include detailed photographic records for the adjacent buildings and structures before and after blasting, in order to avoid later claims by public.

The Contractor shall arrange for the discontinuance of any services to the structure or structures in accordance with the requirements and/or regulations of the Service Authority or Company concerned. The Contractor shall disconnect and properly seal in an approved manner any sewer outlets that serve any structure he is to remove. The Contractor shall keep the Engineer informed of his plans for the performance of any work in connection with sealing off of such outlets in order that proper inspection can be provided at the time the work is performed.

The Contractor shall conduct his operations in such a manner as to avoid hazards to persons and vehicles. After work is started on any structure the work on that structure shall be continued to completion promptly and expeditiously.

The Contractor in submitting his Tender shall include the cost of removing any additional small "out-buildings" which have not been shown on the Drawings.

Immediately upon award of the Contract and prior to the demolition of any structures, the Contractor shall be required to paint or stencil in contrasting colors the following sign in Arabic and English using an oil or lead-based paint on all four sides of each structures or residence:

BUILDING TO BE REMOVED FOR MOTORWAY CONSTRUCTION TO BE DEMOLISHED BY THE CO.
VANDALS WILL BE PROSECUTED

The Signs will be positioned in a prominent location on the structures and/or residences so that they can easily be seen and read, and be at a sufficient height to prevent defacing. The Contractor shall not paint signs or start demolition of any structure prior to the time that the Employer becomes the owner of that structure.

207.05 REMOVAL OF UNDERGROUND PITS, CHAMBERS, CESSPOOLS AND SIMILAR FACILITIES

Underground pits, chambers, cesspools and similar facilities shall be demolished to a depth of 1 meter below the ultimate grade in the area, and shall be properly cleaned out to full depth and backfilled with approved compacted material in accordance with Clause 203.08 of these Specifications.

All debris, sediment and refuse etc., shall be disposed of in accordance with Clause 207.01.5 of these Specifications.

207.06 REMOVAL OF UNDERGROUND STORAGE TANKS

Existing underground storage tanks on the site or under structures designated for removal shall be removed and disposed off by the Contractor. The Contractor shall take all necessary precautions during the removal and disposal of any fluid within the tanks and of the tanks themselves.

All debris, sediment and refuse etc., shall be disposed of in accordance with Clause 207.01.5 of these Specifications. Backfilling shall be in accordance with Clause 203.10 of these Specifications, using an approved material.

207.07 DEMOLITIONS AND REMOVAL OF BOX CULVERTS, PIPELINES, MANHOLES, INLETS, GULLEYS AND SIMILAR UTILITIES

207.07.1 General

Culverts and other drainage structures in locations traversed by traffic shall not be removed until approved arrangements have been made by the Contractor to maintain the flow of traffic.

Designated existing box culverts, pipelines, manholes, inlets, gulleys and similar facilities for drainage or other specified utilities shall be totally or partially demolished as specified, all debris removed, the facility thoroughly cleaned out and the resultant void backfilled with suitable compacted material.

The Contractor shall liaise with the Engineer and shall notify all Utility Owners and co-operate with them in respect of removals and relocations.

Unless shown otherwise on the Drawings, realignment or relocation of the existing active Utilities will be the responsibility of the Contractor unless the Utility Owner indicates his intention to carry out such work by himself, and such works shall be coordinated with the Utility Owner and the Employer. The Contractor shall make the necessary coordination with the relevant Utility Owners ahead of time in order to avoid unnecessary delay to the Contract.

The removal of all disconnected or abandoned Utilities within the ROW shall be carried out by the Contractor, unless the Utility Owner indicates his intention to carry out such removal and the salvaging of materials, fittings, parts, etc.

The Contractor shall liaise with the Engineer and shall advise each affected Utility Owner in writing of his proposed construction schedule and liaise with the Employer who will arrange for inspection by the Utility

Owners who will coordinate any interruption or disconnection of the Utilities as appropriate.

The Contractor shall be responsible for supporting and protecting realigned Utilities, and existing Utilities that are to remain in place, for the duration of the Contract and shall provide all necessary Temporary Works in this respect, all in compliance with the general specification of the relevant Utility Owner for such support and protection works. Any damage caused to Utilities and attributable to the Contractor shall be repaired at his expense.

207.07.2 Total Removal of Culverts

The culvert top slab, walls, base slab and all manhole shafts etc., shall be broken out and all debris removed and disposed of in accordance with the Clause 207.01.5 of these Specifications. Manhole covers and frames shall be carefully removed, cleaned and transported to and stored at designated Ministry of Public Works storage areas unless otherwise specified on the Drawings or directed by the Engineer.

207.07.3 Partial Removal of Culverts

The top slab of the culvert shall be removed together with all manhole shafts etc. The side walls shall be broken out to the specified level or to a minimum of 1 meter below the ultimate grade in the area.

The walls shall be neatly trimmed off and the reinforcement shall be cut or burned off close to the concrete and made safe.

Manhole covers and frames shall be carefully removed, cleaned, transported to and stored at designated Ministry of Public Works storage areas unless otherwise specified on the Drawings or directed by the Engineer.

The remaining section of the culvert shall be thoroughly cleaned out and all debris, sediment, refuse and other unsuitable material disposed of in accordance with Clause 207.01.5 of these Specifications.

The culvert shall be backfilled with approved compacted material.

207.07.4 Abandoned Pipes and Culverts

Where shown on the Drawings or when directed by the Engineer, pipes and culverts no longer required shall be abandoned in place and either filled with grout or concrete, or left empty as specified on the Drawing.

All ends of abandoned pipes with a nominal diameter greater than 100 mm and less than 600 mm and all ends of abandoned culverts with a cross sectional area of 1.0 m^2 or less shall be plugged as specified herein.

All ends of abandoned pipes with a nominal diameter of 600 mm or greater and all ends of abandoned culverts with a cross sectional area greater that 1.0 m^2 provided with a cutoff wall as specified herein.

The treatment of manholes and access shafts on abandoned pipelines and culverts shall be as specified in Clause 207.07.10 of these Specifications except that the manhole or shaft shall be sealed with a capping slab and the manhole/access shaft need not be cleaned out and backfilled.

207.07.5 Total Removal of Pipelines and Recovery of Pipes and Fittings

A. <u>Removal of Pipelines</u>

Where specified on the Drawings or where directed by the Engineer, pipelines, manholes and fittings together with any plain or reinforced concrete bed, haunch or surround shall be broken out, removed and disposed of in accordance with Clause 207.01.5 of these Specifications.

Manhole covers and frames shall be carefully removed, cleaned, transported to and stored at designated Ministry of Public Works storage areas unless otherwise specified on the Drawings or directed by the Engineer.

B. <u>Recovery of Pipes and Fittings</u>

Where existing pipelines are specified to be recovered, the Contractor shall carry out all works as specified in sub-section (a) of this Clause regarding the Removal of Pipelines except that he shall remove pipes and fittings in such a way as to leave them undamaged and suitable for re-use.

The method of taking apart the pipes and fittings shall be agreed with the Engineer prior to the start of the work,

but such agreement will in no way relieve the Contractor of his responsibility to ensure the pipes and fittings are undamaged upon removal.

Repairs to materials damaged in the process of recovery shall be the responsibility of the Contractor.

The pipes and fittings shall have extraneous material including concrete surround carefully removed, they shall then be thoroughly cleaned, loaded and delivered to the storage area designated by the Engineer within 60 km of the source, and be unloaded and stored as required or as directed.

All debris shall be disposed of in accordance with Clause 207.01.5 of these Specifications.

207.07.6 Partial Removal of Pipes

Where specified on the Drawings or where directed by the Engineer, pipes greater than 800 mm in diameter shall be partially removed. Concrete surround (if any) shall be removed to half depth and the pipe broken out to half depth, the concrete trimmed neatly and all reinforcement cut or burned off close to the concrete and made safe. All debris shall be removed and the remaining half pipe cleaned out and all sediment, refuse and other unsuitable material disposed of in accordance with Clause 207.01.5 of these Specifications.

The half pipe shall be backfilled with approved compacted material.

207.07.7 Grouting of Pipelines

Where specified on the Drawings or when directed by the Engineer pipelines 300 mm or less in diameter shall be completely filled with a sand-cement grout approved by the Engineer. Each end of the pipe shall be plugged as specified herein.

The Contractor shall submit for approval his proposed method of grouting the pipes. No grouting shall commence until the Engineer's approval has been obtained.

The Contractor may propose alternative methods of filling the pipe for the approval of the Engineer, together with detailed costing of the method. If acceptable to the Engineer any consequential saving shall be passed on to the Employer, if however, the alternative proposed method is more expensive, the Contractor shall only be entitled to the rate quoted in the Bills of Quantities for grouting of pipelines.

The Engineer shall retain the right to specify that certain pipes shall be filled with grout irrespective of any approval to alternative methods of filling.

Pipe grouting shall be carried out prior to backfilling where the adjacent pipes have been removed. Backfilling may commence only on written confirmation from the Engineer that the grouting is acceptable.

Where an abandoned pipeline is specified to remain undisturbed in the ground, the Drawings may show, or the Engineer may direct, that certain lengths are to be filled. The method by which the filling is to be achieved is to be agreed with the Engineer.

207.07.8 Plugging of Pipelines

Where specified on the Drawings or where directed by the Engineer pipes shall be plugged by Class K180 concrete to a minimum 1 meter extent.

The method of constructing the plug to ensure a solid watertight seal shall be approved by the Engineer.

Plugs shall be constructed prior to backfilling where adjacent pipes have been removed, and backfilling may commence only on written confirmation from the Engineer that the plug is acceptable.

207.07.9 Cut-off Walls and Capping Slabs

Where specified in the Documents or where directed by the Engineer the Contractor shall construct a reinforced concrete cut-off wall to box culverts and pipelines and a reinforced concrete capping slab to manholes and access shafts.

The Contractor shall submit details of the reinforced concrete wall for the Engineer's approval prior to commencing work on the construction of the wall/slab.

207.07.10 Manholes and Access Shafts

Unless otherwise indicated in the Documents or directed by the Engineer manholes and/or access shafts shall be broken out and disposed of to a plane not less than 1 meter below the ultimate grade in the area or to immediately below the manhole and/or access shafts cover slab, whichever is the lower.

The manhole and/or access shafts walls shall be neatly trimmed off and reinforcements shall be cut or burned off close to the concrete and made safe.

Manhole and/or access shafts covers and frames shall be carefully removed, cleaned and transported to and stored at designated Ministry of Public Works storage areas unless otherwise specified on the Drawings or directed by the Engineer.

The manhole and/or access shafts shall be cleaned out and all debris, sediment and refuse and other unsuitable material disposed of in accordance with Clause 207.01.5 of these Specifications, and backfilled with approved compacted material.

207.07.11 Drainage Inlets, Gulleys & Similar Facilities

Unless shown otherwise on the Drawings, all redundant drainage inlets, gulleys and similar facilities shall be broken out to full depth and the debris disposed of in accordance with Clause 207.01.5 of these Specifications.

Gulley covers and frames and drainage inlet covers and frames shall be carefully removed, cleaned and transported to and stored at designated Ministry of Public Works storage areas unless otherwise specified on the Drawings or directed by the Engineer.

207.07.12 Removal of Street Furniture

Where shown on the Drawings, indicated in the Contract Documents or instructed by the Engineer, street furniture shall be recovered, cleaned and either delivered to the store of the designated Authority or set aside for re-erection as part of the works, or shall be removed and disposed of. The work shall include the excavation, removal and disposal of all foundations.

Unless otherwise directed by the Engineer the designated Authorities shall be as follows:

Item	**Designated Authority**
Metal beam guard rail (including posts and all associated fittings)	Ministry of Public Works
Concrete barriers	Ministry of Public Works
Electricity Poles (wood or steel)	Ministry of Electricity and Water
Telephone poles (wood or steel)	Ministry of Communications
Road Signs and Traffic Control Units (comprising signal poles, mast arms, signal heads, controllers, sunshades, etc.)	Ministry of Interior
Bus shelters, bus stops and signs	Kuwait Public Transport Company
All other items	As directed by the Engineer

The recovery of existing street lighting installations shall not form part of the work under this Clause of the Specifications but shall be in accordance with Section 14 (Lighting and Electrical Works) of the Specifications.

207.07.13 Removal of Walls, Rocks and Boulders

Masonry Walls and accumulated stones, large rocks and boulders of individual size greater than 0.2 cu.m. or greater than 500 kg in individual size or weight which lie within the limits of the Works, shall be removed and disposed off as directed.

207.08 MEASUREMENT AND PAYMENT

207.08.1 Method of Measurement and Basis of Payment

A. General

All measurements shall be irrespective of the depth of burial of the various facilities to be demolished, removed or partially removed, recovered, plugged or grouted, and in pricing the payment items the Contractor will be deemed to have taken due account of the depths of burial and the costs of all necessary temporary works, supports, de-watering etc.

The removal of pipelines 100 mm and less in internal diameter, unless designated for recovery, shall not be measured or paid for separately but shall be considered as a subsidiary obligation under this Section of the Bills of Quantities.

Except as otherwise specified herein all payment items shall include for all demolition and removal work as specified herein, for excavation, backfilling and compaction in accordance with Section 2 (Earthworks) of these Specifications and for all necessary temporary works, supports, de-watering and all other items or operations necessary to complete the works in accordance with these Specifications.

Where embankment is to be constructed subsequent to removal of existing pavement, the volume of embankments shall be measured from the level of the underside of the pavement to be removed.

Payment items shall also include for the removal, cleaning, transportation and storage of materials specified to be recovered and for all specified cleaning out and disposal of all debris, sediment, refuse and other unsuitable material.

The Contractor should note that no separate payment in connection with demolition and removal items shall be made for excavation in rock or in unsuitable material, and all payment items shall include for any additional suitable material required to backfill excavations.

No additional payment shall be made for fill material required to backfill voids formed by the removal, or partial removal, of facilities. The Contractor shall be deemed to have allowed for such requirements in the rates entered in the Bills of Quantities.

If the Bills of Quantities does not contain separate items for “Removal of Structures and Obstructions”, this work will not be paid for directly but will be considered as subsidiary work related to other items in the Bills of Quantities.

B. Removal of Existing Pavements

Measurement for the removal of asphaltic pavement shall be by the meter cube of pavement material. Payment shall be at the rate in the Bills of Quantities which payment shall include for the removal and reclaim of pavement materials and delivery to the designated locations and removal and disposal of kerb base and backing, edge beam (if any) etc., and where not specified for recovery, kerbs.

Measurement for the removal and disposal of non-asphaltic pavement not specified for recovery shall be by meter square in the case of precast concrete paving slabs and blocks and by meter cube for all other materials, including plain and reinforced insitu pavement, in all cases measured from outside face of any boundary kerbs or the like not measured separately for removal. Payment shall be at the rates in the Bills of Quantities, which rates shall include for the removal and disposal of all pavement material, associated kerb and edging backing and base concrete and, where not specified for recovery, kerbs and edgings.

Measurement for the recovery of precast concrete paving slabs and blocks shall be by the meter square, in all cases measured from the outside face of any boundary kerbs or the like not measured separately for removal. Payment shall be at the rate in the Bills of Quantities which payment shall include the removal of all slabs and blocks, cleaning and delivery to the designated locations for storage on site and subsequent delivery to the location on site for reinstallation or transporting to and storing at designated MPW storage areas. Payment shall also include for removal and disposal of associated edgings and kerbs, including all base and backing concrete where the edging or kerbs are not specified for recovery, or are not measured separately for removal.

Measurement for the recovery of edging/kerbs shall be by the meter run. Payment shall be at the rate in the Bills

of Quantities which payment shall include the removal of the edging/kerbs, cleaning and delivery to the designated locations or storage on site and subsequent delivery to the location for reinstallation or transporting to and storing at designated MPW storage areas. Payment shall also include for the removal and disposal of edging/kerb base and backing, etc.

Payment for all measures required for building and protecting stockpiles shall be included in the price for Removal of Existing Pavements, and no additional payment shall be made. No work shall be accepted for payment under this pay item in which the Contractor has not complied with the requirements to protect the salvaged pavement from loss and contamination, to protect stockpiles from unauthorized dumping, and to keep separate those salvaged materials which differ in layer thickness and mix type as defined in Clause 207.02.3 of these Specifications. Deduction from the pay quantity shall be made for material which in the judgment of the Engineer or his representative has become contaminated in the course of the work.

Material shall be judged to have become contaminated in the course of the work when it consists of two or more unlike pavements (as defined in Clause 207.02.3 of these Specifications) or when a detrimental amount of soil, rubble, rubbish, or other extraneous substance is present as a result of the Contractor's method of removal or his failure to protect the material. For the purpose of this provision, a detrimental amount of extraneous material is any amount of foreign matter which is liable to disrupt the flow of materials through the crushing and mixing equipment or cause measurable variations in the mixture. Windblown soil, in the absence of other contaminants, shall not be considered as contamination. The Engineer may determine that all or part of a stockpile is contaminated, and this determination shall be made on the basis of visual inspection by the Engineer or his representative.

When directed by the Engineer the Contractor shall remove the contaminated parts of the stockpile and shall weigh this material in the presence of the Engineer or his representative. He shall then dispose of the material in a location approved by the appropriate authorities and in accordance with Clause 102.11of Section 1 (General) of these Specifications and all laws and regulations.

The amount to be deducted from the pay quantity shall be the total volume of rejected material as determined by converting the weight in tones to volume in cubic meters, at the rate of 0.445 cubic meters per tonne.

C. Cutting Back of Existing Construction

No separate measurement or payment shall be made for cutting back existing pavement or other construction. All work shall be included as a subsidiary obligation to the items in the Bills of Quantities.

D. Removal of Fencing and Gates

Measurement shall be by the meter run of fencing removed, and by the meter run of fencing recovered no matter what the style or variety of fencing involved. Measurement shall include gates.

Payment shall be at the rate in the Bills of Quantities for either removal and disposal or removal and recover which rate shall include, but not by way of limitation, all costs involved in dismantling, cleaning including removing concrete from fence posts, transporting to store, and backfilling redundant post holes.

E. Demolition and Removal of Structures

Measurement for the demolition and removal of all structures and related obstacles shall be at the meter square of plan area of the main structure to be removed.

Payment shall be at the rate in the Bills of Quantities which rate shall include the cost of demolition of the main structure and all associated structures (sheds, outbuildings, garages, etc.), all walls, fences, driveways, signs, etc. and their related foundations as shown on the Drawings or as designated by the Engineer.

F. Removal of underground Pits, Chambers, Cess-Pools and Similar Facilities

Measurement shall be by the meter cube of internal volume with depth being measured from corrected (after clearing and grubbing) ground level, finished ground level or sub-grade level whichever is the lowest. Payment shall be made at the rate in the Bills of Quantities, and this shall include for any pumping out and cleaning and filling as directed by the Engineer.

G. Removal of Underground Storage Tanks

Measurement shall be by the number of each type of tank of each quoted approximate size. Payment shall be made at the rate in the Bills of Quantities.

H. Demolition and Removal of Box Culverts, Pipelines, Manholes, Inlets, Gulleys and Similar Utilities

All references to "pipe diameter" in item (i) to (vii) below shall mean "nominal pipe diameter".

i. Removal of Culverts

Measurement shall be by the meter run for each size of culvert. Payment shall be at the rate in the Bills of Quantities. Headwalls, apron slabs etc., shall not be measured or paid for separately but shall be considered incidental to the culvert removal.

ii. Removal of Pipelines and Recovery of Pipes and Fittings

Measurement shall be by the meter run for pipes to be removed and disposed of, and by the meter run for pipes to be removed and recovered.

Measurement shall be made overall including the length of manholes and fittings. Separate items shall be measured for concrete encased pipes and non-concrete encased pipes.

Payment shall be at the rate included in the Bills of Quantities which rate shall be full compensation for the removal and disposal or recovery as specified.

iii. Grouting of Pipelines

Measurement shall be by the meter run of pipeline grouted for each pipeline diameter. Payment shall be at the rate in the Bills of Quantities, which payment shall include end plugs to the pipeline.

iv. Plugging of Pipelines and Culverts

Plugs to pipelines and culverts shall not be measured or paid for separately but shall be considered as incidental to pipeline and culvert removal.

v. Construction of Cut-off Walls and Capping Slabs

Measurement shall be by the meter cube of wall/slab. Payment shall be at the rate in the Bills of Quantities.

vi. Removal of Manholes and Access Shafts

Measurement shall be by the number of each type of manhole/access shaft irrespective of total depth or overall size. Reinforced concrete and block work manholes/access shafts shall be measured separately. Payment shall be at the rate in the Bills of Quantities. Manholes/access shafts on lines designated for removal shall not be measured and paid for separately but shall be deemed to be included in the rate for removal of the pipeline.

vii. Removal of Drainage Inlets, Gulleys and Similar Facilities

Measurement shall be by the number of each particular facility irrespective of total depth and overall size. Payment shall be at the rate in the Bills of Quantities.

Demolition and removal of the facilities included in (i) to (vii) above shall not be measured within the pay limits of excavation of high level areas or structural excavation unless required to be recovered, but shall be deemed to be included in the rate for excavation.

I. Removal of Street Furniture

Measurement for the removal of street furniture shall be by the number of each type of street furniture item recovered, cleaned and delivered to store, of each type recovered and set aside for re-erection and subsequently re-erected or transported and stored at the design storage areas of the relevant Ministry and of each type removed and disposed of.

Measurement for the removal of median cable barrier, median fence with cable, and metal beam guardrail shall

be in accordance with the units and rates set out in the Bills of Quantities for each type of barrier recovered, cleaned of concrete foundation and delivered to store, and for each type removed and disposed of.

Payment shall be at the rates in the Bills of Quantities.

207.08.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
207.1	Removal of asphaltic pavement	cu.m
207.2	Removal and disposal of non-asphaltic pavement not specified for recovery	cu.m
207.3	Removal and disposal of precast concrete paving slabs and blocks	sq.m
207.4	Removal and recovery of precast concrete paving slabs and blocks	sq.m
207.5	Removal and recovery of edging/kerbs	m
207.6	Removal and recovery of fencing and gates	m
207.7	Removal and disposal of fencing and gates	m
207.8	Demolition and removal of structures	sq.m
207.9	Removal of underground pits, chambers, cess-pools and similar facilities	cu.m
207.10	Removal of underground storage tanks (Type/Size)	nr
207.11	Removal of culverts (size)	m
207.12	Removal and disposal of pipelines (concrete encased/not encased)	m
207. 13	Removal and recovery of pipes and fittings (concrete encased/not encased)	m
207.14	Grouting of pipelines (diameter)	m
207.15	Construction of cut-off walls and capping slabs	cu.m
207.16	Removal of manholes/access shafts (concrete/blockwork)	nr
207.17	Removal of drainage inlets, gulleys and similar facilities(Type)	nr
207.18	Removal of street furniture (Type recovered and stored/ Recovered and re-used/disposed)	nr

208 - STRUCTURE EXCAVATION AND BACKFILLING

208.01 GENERAL

In addition to the work specified, the Contractor shall include all operations necessary to excavate and backfill all as required for the construction of the structures as shown on the Drawings, as specified herein and as may be required for all construction.

This work shall consist of the necessary excavating in any material for bridges and other structures and utilities not otherwise provided for in the Specifications; and including all necessary bailing, pumping, dewatering, drainage, sheeting, bracing, and construction and subsequent removal of temporary shoring, cribs and cofferdams. The backfilling of completed structures with suitable approved material and the disposal of all surplus or unsuitable excavated material shall be in accordance with these Specifications and as indicated on the Drawings or as directed by the Engineer. .

The Contractor will be deemed to have satisfied himself, at the time of tendering, as to the type and nature of soils and rock that will be encountered in structural excavations.

The Contractor shall be solely responsible for the safety at all times of all foundation and trench excavations whether supported or otherwise. Approval of the Contractor's support system or omission of a support system for any excavations shall not absolve the Contractor from his sole responsibility in this regard.

The Contractor shall take all necessary precautions, including shoring or otherwise, to protect employees in the excavation and on the ground above. The Engineer will not enter excavated areas to approve the foundation and further works until he deems the areas to be safe.

The sides of all foundation pits and trenches shallower than 1.5m shall be vertical and adequately supported at all times unless otherwise shown on the Drawings. Sides more than 1.5 m in depth shall be sloped at a stable slope or supported in an approved manner unless the material through which the pit or trench is cut is deemed to be sufficiently self-supporting and not requiring support.

Pits and trenches shall be kept free from water until footing concrete has been placed or pipes have been installed. The Contractor shall minimize, to the maximum extent practicable, the length of time excavated areas are open. The Contractor will be held responsible for damage due to weather, equipment, and other causes during periods when the excavations are left open.

The Contractor shall schedule the Works so that no excavation is left in an exposed condition for a period greater than 30 days unless otherwise approved. In where the excavation is adjacent to public highways and walkways, no excavation shall be scheduled to be left in an exposed condition for more than 7 days unless otherwise approved.

For excavation in material sensitive to moisture (stiff clays, marls, etc.) the excavation shall be cleaned and a concrete blinding layer cast immediately on completion of the excavation.

The Contractor must notify the Engineer of any sign of failure or cracks within or around the excavation immediately when such signs are noticed.

Laid back excavation slopes shall not be permitted without the written permission of the Engineer. Where such permission is not granted or where only a part of the overall depth of an excavation is permitted to be laid back, all vertical faces of excavation greater than one and one half meters in height shall be supported unless otherwise agreed in writing by the Engineer. Such agreement shall not relieve the Contractor of his responsibilities under the Contract.

208.02 TEMPORARY SUPPORT SYSTEM

When a temporary support system is required to protect adjacent property or to protect the public during construction, the Contractor's design for such support system shall be submitted for approval prior to commencing its construction.

The proposals shall be submitted in the form of calculations and drawings which clearly indicate the extent of excavation at all points along the structure relative to adjacent properties, roads and services.

In the case of vertical excavations the proposals shall comprise detailed drawings of the support system, stating the method of installation and showing the support member materials, sizes, spacing and engineering calculations to validate the design of the above, including the maximum theoretical deflections of the support members. The support system shall be designed in such a manner that no raker struts or any other support members extend through surfaces exposed in the finished construction, and no shoring or bracing is placed under permanent structures.

The engineering calculations shall be in English and shall show lateral earth pressures for the full excavation depths, forces at various stages of support during installation and removal and concrete placement, the anticipated equipment loads, surcharge loads of any description, the maximum design loads to be carried by various member of the support system and strut preload forces.

If the structure support system proposed includes tie-back anchors, the Contractor’s submittals drawings shall show the profile of the soil in which each anchor is to be installed, the design load for the full depth of the excavation, the maximum design and proof loads, surcharge loads of any description; equipment loads, forces at various stages, support during installation and removal, and the criteria proposed for deformations under proof loads.

Where a proposed system of tie-back anchors projects beyond the vertical projections of the Contract limit lines shown on the Drawings on to the adjoining property, the permission of the owner shall be obtained in writing and such permission submitted to the Engineer at the time the shop drawings of the support system are submitted.

The design of the structure excavation support system specified above shall be prepared by and signed by a professional engineer specializing in this type of design work. The professional engineer shall be approved by the Engineer.

Notwithstanding any approval of temporary support systems, the Contractor shall be solely responsible for the adequacy of their design and construction and for maintenance and all necessary safety precautions associated therewith.

208.03 DEWATERING

At locations where the excavation extends below the ground water table, a de-watering system shall be provided which will effectively reduce the hydrostatic pressure and lower the groundwater levels below excavation levels, as required for the safe and proper excavation of the work and which will result in obtaining a stable, dry subgrade for the execution of subsequent operations.

The Contractor shall design de-watering methods and settling basins so that no critical amounts of soil, sand or silt are removed during either the initial operations or the construction operations. Complete working drawings showing the type of de-watering and ground water control system proposed shall be submitted to the Engineer for his review.

The Contractor's submittal drawings shall show the arrangement, location and depths of the proposed de-watering system if required. A complete description of the equipment and materials to be used and the procedure to be followed shall be shown, together with the standby equipment, standby power supply, and the proposed location or locations of points of discharge of water.

Any required de-watering system design shall also include the measures taken to prevent damage due to settlement of pavement, utilities, sewers, buildings and other structures outside the excavation but within the area affected by the dewatering procedures.

Dewatering shall not be terminated without the approval of the Engineer and in the case of structures retained by ground anchors dewatering shall not be terminated until the ground anchors have been stressed to the full working load and approved by the Engineer.

The design of dewatering system specified above shall be prepared by and signed by a professional engineer specialized in this type of design work. The professional engineer shall be approved by the Engineer.

208.04 EXCAVATION FOR STRUCTURES

208.04.1 Excavation for major structures

The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross-sectional elevations and measurements may be taken, where necessary, of the undisturbed ground and existing structures affected by the proposed structure. Any materials removed or excavated before these measurements have been taken and approved by the Engineer will not be paid for.

Trenches or foundations pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the Drawings, or as ordered by the Engineer, within a tolerance of plus or minus 25 mm.. They shall be of sufficient size to permit the placing of structures or structure footings of the full width and length shown. The elevations of the bottoms of footings, as shown on the Drawings shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary, to secure a satisfactory foundation.

Boulders, logs, and any other objectionable material encountered in excavation shall be removed.

Unless otherwise provided for in the Contract Documents or directed by the Engineer structure excavation shall be carried out for a width of at least 500mm beyond the horizontal outside limits of the foundation, footing or structural member to which the excavation relates. Concrete blinding or subfoundations are not to be considered as structure for the purpose of defining such excavation.

If during the progress of the work, loose, unstable or unsuitable material or improperly compacted soil or any material deemed unsuitable by the Engineer, is encountered below structure foundation level, or adjacent thereto, such material shall be removed and replaced with Class K180 concrete complying with Section 5

"Concrete Works" of these Specifications or with suitable backfill material, as directed by the Engineer.

After each excavation is completed, the Contractor shall notify the Engineer to that effect, and no blinding, footing or bedding material shall be placed until the Engineer has approved the depth of excavation and the character of the material on which the foundations will bear.

All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface, either level, stepped or serrated as directed by the Engineer. All seams or crevices shall be cleaned and grouted. All loose and disintegrated rock and thin strata shall be removed. When the blinding or footing is to rest on material other than rock, excavation to final grade shall not be made until just before the blinding or footing is to be placed and care shall be taken to ensure that the ground at formation or blinding level is not disturbed.

If, in the opinion of the Engineer, the ground becomes disturbed to a depth of not more than 150 mm, and is no longer suitable to receive blinding or foundations, then the formation shall be scarified to a depth of 150 mm followed by compaction to not less than 95% MDD. If necessary, water shall be added to or removed from the material in order to achieve this value, and material added or removed as necessary to achieve the required formation levels. The means of compaction shall be suitable for the material in question and shall be approved by the Engineer.

Should the formation be disturbed to a depth greater than 150 mm, then all of the disturbed material shall be removed and then replaced in layers not exceeding 150 mm, each layer being compacted to 95% MDD as above.

If, in the opinion of the Engineer, the material is so disturbed that it is no longer suitable as a formation material for blinding or foundations, then it shall be removed and alternative material placed in accordance with the requirements for unsuitable material.

208.04.2 Excavation for culverts, pipes and miscellaneous structures

Excavation shall be carried out to the limits required for construction and to the depth required for bedding material or removal of unsuitable material, within a tolerance of plus or minus 25 mm. All trench excavation shall proceed upgrade, commencing at the downstream end.

Material supporting the foundation bedding or structure shall be AASHTO M 145 Class A-1-a, A-1-b or A-2-4 compacted to 95% AASHTO T 180 maximum density. If the natural material does not meet the classification requirements, it shall be sub-excavated to a depth of at least 200mm and replaced with material meeting the specified requirements. Any rock or hard material within 200 mm of the bottom of the pipes shall be similarly subexcavated and replaced with material meeting the specified requirements.

If no special bedding material is required, the foundation for precast and prefabricated culverts shall be formed to the shape of the culvert, including all protrusions. The shaping shall extend to 25% of the height of culvert.

Where rock is encountered in the toe wall excavation for concrete box culverts or concrete cut-off-walls and the rock is of such quality as will prevent erosion, part of the toe wall may be eliminated in the rock strata as directed and the toe wall shall be keyed into the rock strata in a satisfactory manner. The minimum thickness of the key shall be as shown on Drawings or as instructed by the Engineer.

Concrete pipes shall be installed in trenches cut into previously constructed and compacted embankment or from top of subgrade. Unless otherwise shown on the Drawings, trench width shall not be greater than the external diameter of the pipe plus 500 mm on each side.

When excavation is required for installation of ducts, the Contractor shall notify the Engineer upon completion of the excavation. No duct shall be laid until the depth and cross section of the excavation has been approved.

208.05 UTILISATION OF EXCAVATED MATERIALS

All excavated material, so far as it is suitable, shall be utilized as backfill or roadway fill. The surplus material, whether or not temporarily allowed to be placed within a drainage area, shall be disposed of finally in such manner as not to obstruct the drainage or otherwise impair the efficiency or appearance of any structure. No excavated material shall be deposited at any time so as to endanger the partly finished structure.

All excavated material shall be approved by the Engineer before being utilized as fill. All surplus excavated

material and excavated material rejected by the Engineer for use on the site shall be removed from the site and disposed off in locations designated by the Engineer/Municipality within a 60km radius of the site of the work.

The Contractor shall include all handling, off-loading, spreading, leveling, watering and all other related work as directed by the Engineer.

208.06 COFFERDAMS

Suitable and practically watertight cofferdams shall be used wherever water-bearing strata are encountered above the elevation of the bottom of the excavation. Upon request, the Contractor shall submit drawings showing his proposed method of cofferdam construction.

Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottoms of the footings and shall be well braced and as nearly watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

When conditions are encountered which, as determined by the Engineer, render it impracticable to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as directed by the Engineer. The foundation shall then be dewatered and the footing placed.

If weighted cribs are employed and the weight is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorages such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level as directed.

As an alternative to a cofferdam, the Contractor may propose a well-point dewatering system, for approval by the Engineer, to keep structural excavation works dry. Such proposal shall include but not be limited to sufficient calculations, sketches, drawings, etc., to justify the well-point positions and lengths in addition to pumping capacity required. The use of a well-point dewatering system may not preclude the use of support or shoring within the excavation to provide adequate stability and safety to the satisfaction of the Engineer and which shall be provided at no extra cost.

208.07 BACKFILL

208.07.1 General

The Contractor shall obtain approval for his proposed method and rate of placing of backfill before commencing the works.

Backfill materials shall be uniformly graded granular material, capable of being compacted to required compaction, and having adequate permeability to permit free drainage through it. Backfill material shall also conform to the requirements listed below:

Surface	**Requirements**
- Minimum D_{10} value	- 1 mm
- Maximum Plasticity Index	- 8 per cent
- Requirements for bridges, culverts etc. shall be as specified in subsequent Clauses.	

Backfill material shall not be placed against any structure until approval is given. Unless otherwise shown on the Drawings structures shall be backfilled to the same requirements as specified for the adjacent embankment.

Backfill shall be placed in level layers for the full width of the excavated area until the elevation of the original ground or surrounding embankment is reached. Backfill next to walls, between columns or in other confined areas, shall be compacted by approved hand or portable equipment.

Each successive layer of backfill shall contain only sufficient material to ensure proper compaction and in no

case shall any layer be greater than 150 mm thickness (after compaction). The moisture content of the backfill material shall be uniform and within the moisture range designated. Backfill material shall be compacted to 95% of the maximum density as determined by AASHTO T 180 (Method D).

Jetting of fills or other hydraulic methods involving or likely to involve liquid or semi-liquid pressure will not be permitted.

Water shall be drained from the areas to be backfilled wherever practicable. In cases where, in the opinion of the Engineer, it is not practicable to drain the areas to be backfilled, the initial backfill material shall be pervious backfilling according to Clause 209 of these specifications. Such material may be deposited below the standing water level without compaction. Above the water level normal laying and compaction will be considered.

Additional water to be added during placement of backfill material to achieve required compaction shall be fresh water or brackish water approved by the Engineer.

Minimum tests required during backfilling operations to verify material are:

i. One Proctor test for each structure.
ii. One Gradation of Materials when materials changed.
iii. One Plasticity Index and field density for 50% of the layers and for each footing and abutment as per instruction of the Engineer.

208.07.2 Backfilling for box culverts, pipes and miscellaneous structures

Structures shall not be subject to the pressures of backfilling or to live loads until the 28-day strength of the concrete has been reached, unless a shorter period is approved in special circumstances where the load is sufficiently small as not to constitute a risk of any damage to the structure in the opinion of the Engineer. If approved this period may be extended if subnormal curing conditions exist.

Backfill placed around culverts shall be deposited on both sides to approximately the same elevation at the same time. Special care shall be taken to prevent any wedging action against the structure and slopes bounding the excavation shall be stepped, where necessary, to prevent such wedge action occurring.

All backfill intended to support false workloads, including temporary fills shall be designed for the minimum support required. As a minimum, such material shall be AASHTO M 145, Class A-1-a, A-1-b or A-2-4, compacted to 90% of the maximum density as determined by AASHTO T 180 (Method D).

Backfill around retaining walls shall be completed to the level of the original ground line and to such heights above original ground line or to the levels as shown on the Drawings. Care shall be exercised to prevent forward movement of the wall.

Unless shown otherwise on the Drawings, when special permeable backfill (sheathing) is to be placed against the back faces of retaining walls or wing walls, it shall consist of a continuous covering of approved type proprietary filter fabric protected by a continuous wall of 200mm minimum thickness precast, porous (no-fines) concrete blocks laid with dry joints. Prior to construction of the block wall, an approved underdrain or perforated pipe of at least 150mm diameter shall be laid along the base of the wall under the sheathing, where the materials for these underdrains/perforated pipes are given.

Backfill material for culverts, pipes and miscellaneous structures within 300 mm of any part of the structure shall be Class A-1-a, A-1-b or A-2-4. The 300 mm minimum thickness of subgrade layer shall consist of approved subgrade material placed in 2 layers (150mm each) and compacted to 98% maximum density as specified under Clause 206 of these Specifications. The backfill shall be completed to the level of the original ground or to the top elevation of any adjacent embankment.

Backfill around and over pipes shall not commence until headwalls and wingwalls have been constructed and attained the specified 28-day strength.

Water used for compaction of backfill around metal pipes shall be from an approved source and shall not contain more than 0.5% combined chlorides and sulphates nor contain other potentially harmful minerals.

When pipes or other structures temporarily extend above the grade of the partially constructed embankment, the Contractor shall construct the fill over the structure of sufficient depth to protect the structure from any damage

resulting from construction or other traffic.

In no case shall surplus material be dumped in stream channels.

Over-width or over-depth excavation for precast concrete pipes shall be made good at the Contractor's expense by provision of an in situ concrete cradle or increased thickness of concrete bedding as directed, or by the use of other approved suitable materials.

Over width excavation for in situ concrete pipes shall be made good at the Contractor's expense by concrete bedding brought up to the external haunch of the pipe or by the use of other approved suitable materials.

The Contractor shall complete the backfill around box culverts to the level of the original ground line and to the full width of excavation area. If the top of culvert extends above the original ground line the Contractor shall continue the backfill to the top of culvert and for a width of 3 m on each side of the culvert for the full width of roadway embankment. If the embankment is in place at the time of backfilling, the Contractor shall backfill around the culvert to the top of embankment.

Backfill around pipes shall be completed to the level of original ground line and to the full width of excavation area. If the top of the pipe extends above the original ground line the Contractor shall continue the backfill to the top of pipe for a width of 1.5 times the maximum external diameter of the pipe on each side of the pipe centerline to the full width of the roadway embankment. If the embankment is in place at the time of backfilling, the Contractor shall backfill around the pipe to the top of pipe or as shown on the Drawings.

Any existing roadway pavement cut through, damaged or removed during excavation for pipe installation shall be reinstated, after pipe installation and trench backfilling, using approved base and surfacing course materials at least equivalent to those in the original pavement. Materials and construction shall conform to the relevant requirements Sections 3 and 4 of this specification.

Miscellaneous structures other than pipes shall be backfilled in accordance with the methods specified. Compaction of backfill when structures are outside the roadway right-of-way or in approach roads, minor roads or similar areas, shall be to 90% of maximum density as determined by AASHTO T 180 (Method D).

208.08 MEASUREMENT AND PAYMENT

208.08.1 Method of Measurement and Basis of Payment

A. <u>Structure Excavation</u>

Measurement shall be by the meter cube. Payment shall be at the rate in the Bills of Quantities which rate shall include for, but not be limited to, materials, equipment, labour, workmanship, and other related costs, overhead costs and profit for structure excavation, backfilling, dewatering, pumping, excavation support systems, pregrouting, ground stabilization, protecting formation, reworking and recompacting or replacing disturbed formation, and all things necessary to complete the Works in accordance with these Specifications, the Drawings and the instructions of the Engineer.

Further, the unit rate for structure excavation shall include for loading, hauling, offloading, spreading, leveling, watering and other related work as directed by the Engineer.

The volume of structure excavation to be paid for shall be the product of the cross-sectional area of the excavation and the length of each such section.

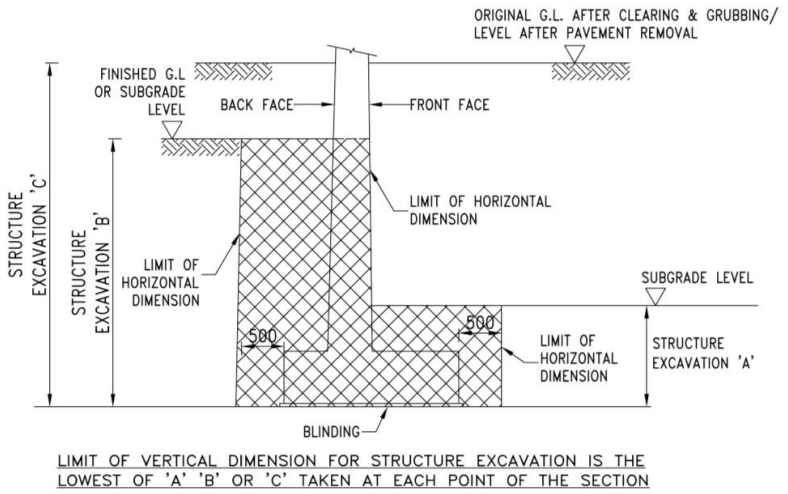
The cross-sectional area shall be determined as indicated in Fig. 208.08.1 and as described below:

Limits for Horizontal Dimensions

i. In sections to be backfilled – vertical planes 500 mm outside and parallel to the neat line of the footings (excluding blinding concrete).
ii. On exposed faces of structure – the exposed face of the structure.

Limits for Vertical Dimensions

The underside of blinding concrete beneath the structure and corrected ground level, finished ground level or subgrade level, whichever is the lowest, at each point across the section.



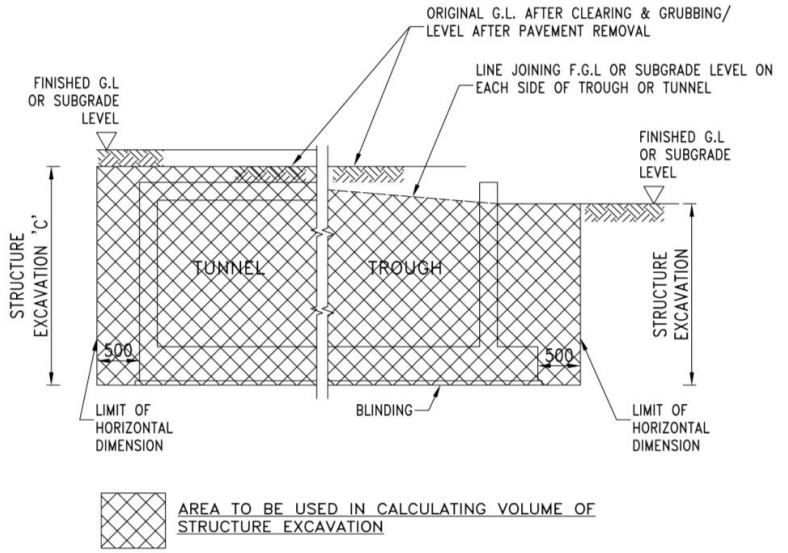


Fig.208.08.1

Where the subgrade is contained on both sides and below for its full width within a structure (e.g. trough or tunnel sections) the limits for vertical dimensions, for the section between the back faces of the retaining walls/abutments forming the trough or tunnel, shall be from underside of the blinding for the structure to the lower of the following:

a. Corrected ground level (after clearing and grubbing)

or

b. An imaginary line from the back face of the retaining walls/abutments on each side of the trough or tunnel section joining the finished ground level or subgrade level, whichever is lower on each side.

Excavation above subgrade level and finished ground level shall be included in excavation for High Level Areas.

In locations where a pavement is to be re-opened to traffic (either temporarily or permanently) on completion of the construction work specified herein, removal and reinstatement of existing pavement courses, precast concrete tiles or blocks and street furniture shall be executed in accordance with Clause 1701of Section 17 "Utilities Structure" of these Specifications.

Measurement and payment for such removal and reinstatement shall be in accordance with Clause 1701 of Section 17 "Utilities Structure" of these Specifications and payment shall be made under Section 2 of the Bills of Quantities.

Structural excavation for box culverts less than one sq.m. in external cross section and structural excavation for pipes, underdrains (subsoil drains), pits, catchbasins, manholes, inlets, energy dissipaters, slope protection Works, fence posts, guardrail posts, lighting columns, sign posts, signal supports and all other minor structures, shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract Prices for Pay Items.

Structural backfilling shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract Prices for Structural Excavation.

In locations where a pavement is not to be so re-opened to traffic (and for pavement removal of temporarily reinstated works), measurement for removal of existing pavement, precast concrete tiles and street furniture shall be according to Clause 207.08 of these Specifications, and payment shall be made under Section 2 of the Bills of Quantities.

B. Rock Excavation

The method of measurement and payment for rock excavation will be as defined in Clause 205 of these Specifications.

C. Concrete Backfill

Measurement for Class K180 concrete used for backfilling, when directed by the Engineer, shall be by the meter cube. Payment shall be at the rate indicated in the Bills of Quantities which payment shall be full compensation for furnishing all materials, labour and equipment to complete the work.

D. Structure Excavation Support Systems

Unless itemized in the Bills of Quantities, all expenses for the design and construction of structure excavation support systems shall be considered incidental to the structure excavation and shall not be measured or paid for separately.

No separate payment shall be made for cofferdams, which shall be included in the rate for structure excavation.

When itemized in the Bills of Quantities, structure excavation support systems shall be measured as per Section 26 "Excavation Support and Protection" of these Specifications. Payment shall be at the rate indicated in the Bills of Quantities.

E. Dewatering System

No separate measurement for well-point dewatering which shall be included in the rate for structure excavation.

Dewatering, including system design, equipment, pumping and disposal of water shall not be measured or paid for separately, but shall be considered incidental to the excavation work.

When itemized in the Bills of Quantities, dewatering system shall be measured as per Section 25 "Ground Water Control" of these Specifications. Payment shall be at the rate indicated in the Bills of Quantities.

208.08.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
208.1	Structure Excavation	cu.m
208.2	Extra Over for Rock Structure Excavation	cu.m
208.3	Concrete Backfill	cu.m

209 - PERVIOUS BACKFILL

209.01 DESCRIPTION

This work consists of furnishing, placing, compacting and finishing pervious backfill material for use in backfilling trenches, under, around and over underdrains, behind retaining walls and bridge abutments, for drainage blankets and other subdrainage purposes when called for on the Drawings, or in these Specifications.

In case a drainage blanket is required in the design Drawings to be installed directly underneath the subgrade, then the subgrade material should respect the filter criteria specified under Clause 209.03 below.

209.02 MATERIALS FOR PERVIOUS BACKFILL AND DRAINAGE BLANKET

The pervious material shall be, clean, hard, durable rapid draining crushed stone or crushed or uncrushed gravel free from organic material, clay balls or other deleterious substances, conforming to the properties provided below:

Property	Range
Permeability in m/day – ASTM D2434	300 - 1500
Effective Porosity	0.25
% Fractured Faces – (COE Method)	Min. 75%
Cu (D60/D10)	> 3.5
L.A. Abrasion – AASHTO T96	< 40%
California Bearing Ratio (CBR) – AASHTO T193	> 30%
Sand Equivalent – AASHTO T 176	> 45%
Effective angle of internal friction – AASHTO T 236	> 35°

Table 209.02.1 Properties of Rapid Draining Materials for use in Pervious Backfill and Drainage Blanket

The type of pervious material shall be stated on the Drawings or in the Specifications. Otherwise Type I shall be furnished. The percentage composition by weight of pervious material in place shall conform to the following gradings when determined in accordance with AASHTO test methods:

Sieve Sizes	Percentage Passing			
	Pervious BackFill			Drainage Blanket
	Type I	Type II	Type III	
inch 1-1/2	100	90-100	100	100
inch 1	-	-	-	70-100
inch 3/4	95-100	90-100	95-100	55-100
inch 1/2	50-100	40-100	70-100	40-80
inch 3/8	15-55	25-40	0-55	30-65
No.4	0-25	18-33	0-10	10-50
No.8	0-10	5-15	0-5	0-25
No.200	0-5	0-5	-	0-5

Table 209.02.2 Gradations of Pervious Backfill and Drainage Blanket

209.03 FILTER LAYER MATERIAL PROPERTIES

The layer directly underneath the drainage blanket and the one directly above it shall satisfy the following filter criteria:

i. The 15% size of Filter ($D_{15\ Filter}$) should not be greater than 4 times the 85% size of the surrounding material ($D_{85\ Surrounding\ material}$):

$$D_{15\ Filter} < 4\ D_{85\ Surrounding\ material.}$$

ii. The 15% size of Filter ($D_{15\ Filter}$) should not be less than 4 times the 15% size of the surrounding material ($D_{15\ Surrounding\ material}$):

$$D_{15\ Filter} > 4\ D_{15\ Surrounding\ material.}$$

iii. The 50% size of Filter ($D_{50\ Filter}$) should not exceed 25 times the 50% size of the surrounding material ($D_{50\ Surrounding\ material}$):

$$D_{50\ Filter} < 25\ D_{50\ Surrounding\ material.}$$

iv. The plasticity index of the portion of all filter materials passing sieve # 40 should not exceed 6%.

The filter materials should not contain more than 5% material passing through sieve # 200.

209.04 CONSTRUCTION REQUIREMENTS

Pervious backfill material shall be placed in the areas designated on the Drawings, Specifications, or as designated by the Engineer. The material shall be placed in layers not to exceed 150 mm thickness with no layer less than 75 mm thick when compacted.

Compact pervious backfill and drainage blanket to a density of not less than 95% of the maximum dry density as determined by AASHTO Designation T180 Method C.

209.05 MEASUREMENT AND PAYMENT

209.05.1 Method of Measurement and Basis of Payment

Pervious backfill and Drainage blanket shall be measured by the meter cube in place of aggregate materials, furnished, screened, washed, placed, spread, compacted, completed and accepted. Measurements shall be of volumes computed from the cross sections shown on the Drawings considering the approved field measurements of area and compacted depth of each trial section.

Volumes will be computed from cross-sections measurements by the average end area method. When it is impractical to determine pervious backfill volumes by cross-sections, acceptable methods utilizing three-dimensional measurements will be used.

No measurement shall be made for direct payment of overdepth construction, regardless of the Engineer's permission for it to remain in place.

Payment shall be at the rate included in the Bills of Quantities which rate shall be full compensation for furnishing all materials, including haul, watering, processing, compacting and for furnishing all labour, equipment, tools and incidentals to complete the work.

209.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
209.1	Pervious Backfill	cu.m
209.2	Drainage Blanket	cu.m

210 - GEOTEXTILE

210.01 DESCRIPTION

Applications for the geotextile include subsurface drainage or filtration (to allow for long term passage of water into a subsurface drain) and in soil separation (to prevent the mixing of a subgrade soil and an aggregate cover material).

The Contractor shall furnish and install geotextile fabric at locations and to the lines and grades shown on the Drawings or as directed by the Engineer. Geotextile fabric shall be supplied, tested or suitably certified, and as placed on the prepared roadway sub grade and at the other locations prepared for its use to restrain soil movement, to provide for drainage, and/or to prevent soil erosion.

210.02 MATERIAL

Geotextile fabrics shall comply with AASHTO M288. The physical characteristics of the geotextile for subsurface drainage or filtration shall comply with Clause 7.2 of AASHTO M288 when subjected to tests indicated therein. The physical characteristics of the geotextile for soil separation shall comply with Clause 7.3 of AASHTO M288 when subjected to tests indicated therein.

Geotextile fabric shall be supplied, tested or suitably certified, and placed at the prepared locations shown on the Drawings or as directed by the Engineer.

At the discretion of the Engineer, random samples of fabric from any or all rolls of fabric delivered to the jobsite shall be tested prior to use. Such samples of material shall be tested at a laboratory approved by the Engineer for the purpose of verifying the certification provided. Any sample of material that fails to pass the specified requirements or material that does not fully comply with these specifications shall subject the entire roll of fabric to rejection by the Engineer. To insure proper control of fabric delivered to the jobsite, each roll shall be marked and identified by date of delivery and an alphanumeric designation approved by the Engineer.

The fabric shall be supplied in rolls wound on a suitable disposable paper tube or other non-abrading resilient tube that has an outside diameter of not less than 10 cm. The width of fabric supplied on each roll shall be such as to minimize the development of longitudinal and transverse overlaps. Where longitudinal overlaps are required the width of fabric used shall be not less than 4.5 m. A narrower width may be used if the number of longitudinal overlaps is the same as would be developed using the minimum fabric width of 4.5m. Where transverse overlaps are required, the minimum length of fabric on a roll shall be 90m. Shorter lengths of fabric may be employed provided that the number of overlaps resulting there from is the same as that developed using the specified 90 minimum length rolls.

Sound stitching of geotextile sheets may be allowed as directed by the Engineer.

210.03 METHOD OF INSTALLATION

Installation shall comply with the following requirements unless otherwise directed by the Engineer.

The sub-grade surface to receive the geotextile fabric shall be in a relatively smooth condition free from obstructions, depressions and debris. The geotextile fabric shall not be laid in a stretched condition, but shall be laid loosely with the long dimension parallel to the centerline of the pavements. In the event the width of the proposed area for fabric requires more than one panel width of fabric, the panels shall be overlapped a minimum of 0.3 meters on a firm level sub grade and 1.0 meter on soft, uneven ground. To prevent slippage of the over-lapping fabric, the areas of overlaps shall be stabilized as approved by the Engineer with pins, anchor blocks or aggregate piles. In the event construction machinery is used to place the fabric, the working platform for the machinery shall be the existing soil and not the previously laid fabric.

The aggregate material shall not be dumped directly on the fabric, nor shall the haul trucks run on the fabric. The aggregate shall be spread by a bulldozer or front-end loader. The blade or bucket shall be kept sufficiently high so that the aggregate is not being pulled over the fabric, but is being dropped at a minimum height to the satisfaction of the Engineer. The aggregate material shall be compacted in accordance with Section 3 (Aggregate Sub base and Base Course) of these Specifications.

Fabric damaged or displaced before or during installation or during placement overlying aggregate material shall be replaced or repaired at the Contractor’s expense to the satisfaction of the Engineer.

Geotextile fabric Type 1 shall be used only at locations where at least 15 cm of aggregate material will be in contact with the fabric and soil movement or subsidence is not anticipated by the Engineer. Geotextile fabric Type 2 is to be used at all other locations except as otherwise approved by the Engineer. Construction equipment shall not be permitted to transverse the area of fabric placement until at least 15 cm of suitable material has been placed over the fabric to form a surface protecting the fabric from the stress effects of such equipment.

210.04 MEASUREMENT AND PAYMENT

210.04.1 Method of Measurement and Basis of Payment

Measurement and Payment for the finished geotextile Fabric will be made by the meter square of surface area (regardless of type) of the approved geotextile fabric installation at the unit rate as included in the Bills of Quantities. Such payment will be considered as full compensation for all materials, labour, tools, equipment and appurtenances required for the installation of geotextile fabric, supply and installation of the geotextile fabric, supply and installation of securing pins: and all work necessary to comply with the requirement for the complete geotextile fabric supply and installation.

No additional payment will be made for the required fabric overlaps nor for trimming wastes along edges.

No additional payment will be made for replacing damaged geotextile fabric.

No additional payment will be made for replacing incorrectly installed geotextile fabric.

210.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
210.1	Geotextile Fabric for subsurface drainage or filtration	sq.m
210.2	Geotextile Fabric for separation	sq.m
210.3	Geotextile Fabric for strengthening	sq.m
210.4	Geotextile Fabric for separation and strengthening	sq.m

211 - GEOGRID

211.01 DESCRIPTION

Applications for the geogrid shall include the reinforcement of the subgrade and/or aggregate base/subbase layers within the pavement structure of the roadways and parking lots. The geogrid reinforcement design details, such as the geogrid type, fill thickness, pavement cross-section and other associated details, shall be as shown on the Contract Drawings. The works shall consist of furnishing, storing, cutting, and placing geogrids in accordance with these Specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the Contract Drawings or as established by the Engineer.

211.02 MATERIALS

Geogrids shall be supplied from approved sources and specialized manufacturers. The manufacturing company profile shall be submitted along with the method statement proposed for handling and installation of the geogrid, product samples of a minimum area of 100mm x 200mm, product data sheet and certification submitted by the manufacturer from an approved international testing agency that the geogrid product supplied meets the requirements of these Specifications.

The geogrid shall be integrally formed and deployed as a single layer having the following characteristics:

- Product Type: biaxially or triaxially oriented grid structure formed from an extruded sheet that is punched and then stretched.
- Polymer: Virgin Polypropylene.
- Load Transfer Mechanism: Positive Mechanical Interlock.
- The geogrid material properties shall comply with the requirements indicated in Table 211.02.1.

211.03 STORAGE AND PROTECTION

- Prevent excessive mud, wet concrete, epoxy, or other deleterious materials from coming in contact with and affixing to the geogrid materials.
- Rolled geogrid materials may be laid flat or stood on end.
- Geogrid materials should not be left directly exposed to sunlight for a period longer than recommended by

the manufacturer.

211.04 INSTALLATION REQUIREMENTS

211.04.1 Examination

The Contractor shall record individual roll numbers and shall check the geogrid upon delivery to verify that the proper material has been received. The geogrid shall be inspected by the Contractor to be free of flaws or damage occurring during manufacturing, shipping, or handling.

211.04.2 Preparation

The surface of the installation level shall be prepared as indicated on the Drawings or as directed by the Engineer.

Index Properties	**Test Method**	**Units**	**Minimum Average Roll Values (unless a range or characteristic is indicated)**
Rib Shape	Observation	N/A	Rectangular or Square
Aperture Dimensions (Nominal dimensions)	I.D. Callipered	mm	25 - 33
Minimum Rib Thickness (Nominal dimensions)	Callipered	mm	0.75 or 1.25 (as shown on Drawings)
Tensile Strength @ 2% Strain	ASTM D 6637	kN/m	4.0 – 9.0
Tensile Strength @ 5% Strain	ASTM D 6637	kN/m	8.5 - 19.5
Ultimate Tensile Strength	ASTM D 6637	kN/m	12.5 – 28.5
Structural Integrity			
Junction Efficiency (load transfer capability as % of ultimate tensile strength)	GRI-GG2-87	%	93
Flexural Stiffness	ASTM D1388	mg-cm	250,000 for a 0.75mm min. rib thickness and 750,000 for a 1.25mm min. rib thickness
Aperture Stability (Modulus at 20 kg-cm)	U.S.A.C.E. Method Kinney-01	kg-cm/deg	3.2 for a 0.75mm min. rib thickness and 6.5 for a 1.25mm min. rib thickness
Durability			
Resistance to Installation Damage	ASTM D5818 and D6637	%SC / %SW / %GP	95/93/90
Resistance to Long Term Degradation	EPA 9090 immersion testing	%	100
Resistance to UV Degradation	ASTM D4355	%	100

Table 211.02.1 Geogrid Material Properties

211.04.3 Installation

The geogrid shall be laid at the proper elevation and alignment as shown on the Drawings.

The geogrid shall be installed in accordance with the installation guidelines provided by the manufacturer or as directed by the Engineer.

The geogrid may be temporarily secured in place with ties, staples, pins, sand bags or backfill as required by fill properties, fill placement procedures or weather conditions or as directed by the Engineer.

211.04.4 Granular Fill Placement over Geogrid

Granular fill material shall be placed in lifts and compacted as specified under the relevant Sections of these Specifications. Granular fill material shall be placed, spread, and compacted in such a manner that minimizes the development of wrinkles in the geogrid and/or movement of the geogrid.

A minimum loose fill thickness of 150mm is required prior to operation of tracked vehicles over the geogrid. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid. Rubber-tired equipment may pass over the geogrid reinforcement at slow speeds (less than 15 km/h) when integrally-formed geogrids are used. When multi-layer or welded-strip geogrids are used, rubber-tired equipment shall not be allowed directly on the geogrid. Sudden braking and sharp turning movements shall be avoided.

211.04.5 Inspection

The Engineer or Engineer's representative may randomly inspect geogrid before, during and after installation.

Any damaged or defective (i.e. frayed coating, separated junctions, separated layers, tears, etc.) will be repaired/replaced in accordance with Clause 211.04.6 of these Specifications.

211.04.6 Repair

Any roll of geogrid damaged before, during and after installation shall be replaced by the Contractor at no additional cost to the Employer.

Proper replacement shall consist of replacing the affected area + 1m of geogrid to either side of the affected area.

211.04.7 Protection

The manufacturer's recommendations regarding protection from exposure to sunlight shall be properly followed by the Contractor.

211.05 MEASUREMENT AND PAYMENT

211.05.1 Method of Measurement and Basis of Payment

Measurement and Payment for the item "geogrid" will be made by the meter square of surface area (regardless of type) of the approved geogrid installation at the unit rate as included in the Bills of Quantities. Such payment will be considered as full compensation for all materials, labour, tools, equipment and appurtenances required for the installation of geogrid, supply and installation of the geogrid material, supply and installation of securing pins, ties, staples, sand bags, etc and all work necessary to comply with the requirement for the complete geogrid supply and installation.

No additional payment will be made for the required geogrid overlaps nor for trimming wastes along edges.

No additional payment will be made for replacing damaged geogrid pieces.

No additional payment will be made for replacing incorrectly installed geogrids.

211.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
211.1	Geogrid	sq.m

SECTION 3: SUB-BASE AND BASE COURSES

300 - GENERAL

300.01 SCOPE

This Section contains the Materials, Equipment and Construction requirements for Aggregate and stabilized Sub-base and Base Courses all as and where shown on the Drawings. Requirements for Asphaltic Concrete Base Course are contained in Section 4 of these Specifications.

300.02 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section:

AASHTO

M 85 Specification for Portland Cement (Type-I)
M 85 Specification for Sulphate Resistance Cement (Type-V)
M 216 Specification for Lime for Stabilization
T 2 Sampling of Aggregate
T 22 Determining the Compressive Strength of Cylindrical Concrete Specimens
T 26 Test for Quality of Water to be used in Concrete
T 27 Sieve Analysis of Coarse and Fine Aggregates
T 88 Performing the Particle Size Analysis of Soils
T 89 Determining the Liquid Limit of Soils
T 90 Determining the Plastic Limit and Plasticity Index of Soils
T 96 Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
T 104 Soundness of Aggregate by Use of Sodium Sulphate or Magnesium Sulphate
T 126 Making and Curing Concrete Test Specimens in the Laboratory
T 134 Moisture-Density Relations of Soil-Cement Mixtures
T 135 Wetting-and –Drying Test of Compacted Soil-Cement Mixtures
T 165 Standard Method of Test for Effect of Water on Compressive Strength of Compacted Bituminous Mixtures
T 167 Determination of Compressive Strength of Hot-Mix Asphalt
T 180 Moisture-Density Relations of Soils, using a 10 1b (4.54 kg) Rammer and an 18 in (457 mm) Drop
T 191 Density of Soil In-place by the Sand-Cone Method
T 193 The California Bearing Ratio
T 211 Determination of Cement Content in Cement Treated Aggregate by the Method of Titration
T 220 Determination of Strength of Soil-Lime Mixtures
T 230 Determining Degree of Pavement Compaction of Bituminous Aggregate Mixtures
T 245 Resistance to Plastic Flow of Bitumen Mixture Using Marshall Aparatus

BS

BS 12 Specification for Portland Cement BS 812- 05.1:1989 Testing aggregates. Methods for determination of particle shape. Flakiness index BS1881
108:1983 Method for Making Test Cubes from Fresh Concrete
BS 4027 Specification for Sulphate Resisting Portland Cement

ASTM

C 88 Standard Test Method for Soundness of Aggregate by Use of Sodium Sulphate or agnesium Sulphate
C 131 Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
D 2419 Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
D 2940 Standard Specification for Graded Aggregate Material for Bases or Sub-bases for Highways or Airports
D 4829 Standard Test Method for Expansion of Soils

301 - CONTROL OF MATERIALS FOR SUB-BASE AND BASE COURSES

301.01 MATERIALS

Materials specified for use in the construction of the sub-base and base courses for flexible and rigid pavements, may include any or all of the following:

a. Granular screened material, or partially crushed of approved classes, consisting of well graded gravel including sand and silt, or crushed stone or crushed gravel for sub-base course construction.

b. Crushed stone, of approved classes, for base course construction.

All material sources and the quality of materials proposed for use in the Works shall be approved prior to procuring or processing material from such sources. Inspection, sampling, testing and retesting as necessary, shall be at the Contractor's expense and as specified hereunder for specific materials.

301.02 SOURCES OF MATERIALS

Locating sources and manufacturers of materials in accordance with the quality requirements of the Specifications are the responsibility of the Contractor, who shall produce the required granular materials and aggregates at the rates and in the quantities necessary to complete the Works on time. All materials shall be tested and approved before use.

The Contractor shall have satisfied himself as to the location, suitability and quantity of materials available; extent of work necessary to obtain the material available; the work required to open the quarry and to crush, screen and wash the materials; and the length of haul to the Site.

Prior to starting quarry or borrow pit operations; the Contractor shall obtain written permission from the Authorities or Owners concerned.

Screening plants or crushing and screening plants shall not be put into operation prior to their approval. If, after any plant is put into operation, it fails to perform as intended, the Contractor shall either rectify the defects in the existing plant to the satisfaction of the Engineer, or shall provide alternative approved plant.

Approval of the crushing and screening plants and other equipment shall in no way relieve the Contractor of his responsibilities in respect of producing granular materials and aggregates which conform to the Specifications and in the quantities required for the completion of the Works on time.

301.03 STORAGE AND HANDLING OF MATERIALS

Materials shall be so stored and handled as to assure the preservation of their quality and fitness for the work. Materials, even though approved before storage or handling, may again be inspected and tested prior to use in the work. Stored materials shall be located so as to facilitate their prompt inspection. All storage sites shall be restored to their original condition at the Contractor’s expense prior to acceptance of the Works.

Handling and stockpiling of aggregates shall at all times be such as to eliminate segregation or contamination of the various sizes. Stockpiles shall be kept flat and the formation of high cone-shaped piles shall not be permitted. Heights of granular material and aggregate stockpiles shall not exceed 3 m berms. When conveyor belts are used for stockpiling aggregates, the Engineer may require the use of baffle chutes or perforated chimneys.

When trucks are used to construct stockpiles, the stockpiles shall be constructed one layer at a time with trucks depositing their loads as close to the previous load as possible. The use of tractors or loaders to push material deposited at one location to another location in the stockpile shall not be allowed during the construction of the stockpile and their use shall be limited to leveling the deposited material only. Stockpiles of aggregate located at permanent asphalt plant sites shall be separated by bin walls and shall be constructed on asphaltic or concrete floors. Stockpile locations and procedures at temporary asphalt plant sites shall be as approved by the Engineer.

The Contractor shall take all necessary protection measures in the storage, handling and stockpiling of materials to prevent contamination of materials by dust. The measures that the Contractor proposes to take shall be subject to the approval of the Engineer.

Intermediate storage of hydrated lime and commercial mineral filler for equipment feeding the asphalt plant shall be in silos of adequate sizes to ensure a minimum of one day's continuous operations.

301.04 INSPECTION, TESTING AND CONTROL OF MATERIALS

Samples for testing shall be taken by the Contractor, in the presence of the Engineer. Duplicate samples shall be submitted to the Engineer for future reference, if instructed. Sampling shall be in accordance with AASHTO T2. The Contractor shall conduct the tests in the Site Laboratory, or may have the tests carried out at an approved external laboratory.

The Contractor shall submit to the Engineer, 10 days prior to the scheduled beginning of crushing and screening operations, a statement of origin indicating the aggregate source and the quarry location and qualifications, as well as the types and composition of all stone and/or gravel aggregates and granular materials proposed for use in the Works.

In order to ascertain the properties of granular and aggregate materials, the Contractor shall submit for testing and approval representative samples of all materials intended for incorporation in the Works, prior to starting quarry or borrow pit operations. The representative samples shall be taken by the Contractor in the presence of the Engineer.

Tests performed by the Contractor shall be utilized in assessing the locations, extent of deposits and quantities of materials which will conform to the Specifications when properly processed, and shall in no way obviate the need for further testing by the Engineer. Approval of specific sources of materials shall not be construed as final approval and acceptance of materials from such sources.

The Contractor shall conduct necessary tests in the Field Laboratory in the presence of the Engineer and the Contractor's Materials engineer.

Processed materials shall be tested and approved before being stockpiled on Site or incorporated in the Works and may be inspected and tested at any time during their preparation, storage and use. Questionable materials, awaiting testing and approval, shall not be unloaded and mixed with materials previously approved. If the grading and quality of any materials delivered to the Site do not conform to the grading and quality of the established control samples, the Engineer will reject such materials.

Samples shall satisfy all specified test requirements. The Contractor shall permit the Engineer to inspect any and all materials used or to be used, at any time during or after their preparation, or while being used during progress of the Works. Unsatisfactory materials, whether in place or not, shall be removed promptly from the Site. The Contractor shall furnish all necessary labor, transport, tools and equipment required by the Engineer for such inspections.

For verification of weights and measures, character of materials and determination of temperatures used in the preparation of the asphalt stabilized mixes, the Engineer will at all times have access to all portions of the mixing plant, aggregate plant, storage yards, crushers and other facilities used for producing and processing the materials of construction. The Engineer shall have authority to take samples and perform tests thereon of any material supplied to the Site from any source whatsoever in order to establish their compliance with Specifications and to accept or reject as he deems necessary. Samples shall also be taken from completed work to determine compliance with the Specifications. The frequency of all sampling and testing shall be in accordance with these Specifications and/or as directed by the Engineer.

301.05 SITE LABORATORY

Refer to Section 10 of this specification.

301.06 UNACCEPTABLE MATERIALS

Materials that do not conform to the requirements of the Specifications shall be rejected and removed immediately from the site of the works unless otherwise instructed by the Engineer. No unacceptable construction, the defects of which have been corrected, shall be used until approval has been given by the Engineer.

301. 07 TEST CONDITIONS

Materials which require drying prior to performing any of the specified tests, except those materials which shall be processed in an asphalt drier, shall be dried out at temperatures not greater than 60ºC for soil materials or 100ºC for aggregates.

301.08 WATER

Sea and brackish or saline water shall not be used for spreading and compacting operations for aggregate sub-base and base courses. . The water shall be clean and free from deleterious substances. Water from doubtful sources shall not be used until tested in accordance with AASHTO T126 and approved.

302 - MAJOR EQUIPMENT USED FOR SUB-BASE AND BASE COURSES

302.01 MAJOR EQUIPMENT USED FOR AGGREGATE SUB-BASE AND BASE COURSES

302.01.1 General Requirements

Unless otherwise stipulated herein, all the provisions of Section 2 (Earthworks) of these Specifications in respect of specifications for the main machinery and tools utilized in the Earthworks construction, shall be adhered to, all subject to the following modifications and additions.

302.01.2 Spreaders

Spreaders shall be self-propelled and shall be capable of spreading the sub-base and base materials in one operation so as to make it ready for compaction with minimum shaping. The spreader shall be provided with a screed that strikes off and distributes the material to the required width and level. The width of each spread shall not be less than a traffic lane. The screed shall be adjustable to the required cross-section. Screed action includes any practical motion that produces a finished surface texture of uniform appearance.

302.01.3 Travel Mixers

Travel Mixers shall be of a type which are capable of mixing to the full depth of the layer thickness being processed, by picking up the material, mixing, agitating or otherwise blending into a homogeneous mass which conforms to the required general gradation and other specifications. Mixers shall be equipped with an accurate depth control device to avoid the disturbance of previously accepted layers. After mixing, the material shall be deposited by the mixer in its final position so that prior to compaction no spotting, picking-up or otherwise shifting the material will be required. Mixers may be equipped with pressure spray bars which can supply a uniform distribution of metered water during the mixing process.

302.01.4 Central Mixers

A central mixing plant shall be either of an approved drum or pugmill type with a moisture control system so that the material may be spread without further mixing or processing.

302.02 MAJOR EQUIPMENT USED FOR SAND ASPHALT SUB-BASE AND BASE COURSES

302.02.1 General Requirements

All the provisions of Clause 403 of Section 4 (Asphalt Works) of these Specifications in respect of specifications for the major equipment utilized in the Asphalt Works construction shall be adhered to all subject to the following modifications and additions.

302.02.2 Screens for Asphalt Mixing Plants

The asphalt mixing plant shall be equipped with screens suitable for screening the aggregate into sizes such that they may be recombined into a gradation meeting the requirements of the Job Mix Formula.

However, if the nature of the aggregate, in the opinion of the Engineer is such that no screening is required by reason of its satisfactory natural gradation, then the plant may be equipped with a scalping screen of a size suitable to remove oversize aggregates and other deleterious material.

302.02.3 Rollers

Rolling equipment shall consist of steel wheeled rollers and pneumatic-tyred rollers all as specified in Clause 403.05 of Section 4 (Asphalt Works) of these Specifications, a minimum of three rollers shall be required at all times; one self-propelled pneumatic-tyred and two steel wheeled rollers. As many additional rollers shall be used as necessary to provide the specified density and surface characteristics in any orderly efficient and continuous manner. Tandem steel wheeled rollers shall be of such weight that, under working conditions, will develop contact pressure adequate to obtain the required density.

302.02.4 Unacceptable Equipment

The Engineer shall have the right to stop the use of any equipment or plant which he deems to be inferior to the quality required and to instruct the removal of such equipment and to have it replaced by suitable equipment or to alter the method of operation at any time he so desires.

The Contractor shall immediately comply with such instructions without being entitled to any indemnities or extensions as a result of such instructions. The Contractor shall not be allowed to use any equipment or plant before obtaining the approval of the Engineer, and the Contractor shall undertake to follow sound technical methods and labour to carry out the works. The Engineer shall have the right to expel any operators, mechanics or labour and to instruct suitable replacement thereof at any time he deems such action is necessary.

303 - AGGREGATE SUB-BASE AND BASE COURSES

303.01 GENERAL REQUIREMENTS

303.01.1 Description

Aggregate sub-base and base courses shall consist of crushed mineral aggregates or natural mineral aggregates of the gradation and thickness indicated in the Specifications and on the Drawings. Where the type of aggregate is not specified, it is intended that natural mineral aggregates shall be used.

303.01.2 Natural Aggregate Sub-Base Course

Shall consist of coarse and fine mineral aggregates which have been screened and blended to the various gradings and constructed to the thickness as indicated on the Drawings and in the Specifications.

303.01.3 Crushed Aggregate Sub-Base and Base Courses

Shall consist of crushed coarse aggregate and crushed or natural fine aggregate screened and blended in accordance with the required gradation and constructed to the thickness as indicated on the Drawings and in the Specifications.

303.02 MATERIALS REQUIREMENT FOR AGGREGATE SUB-BASE AND BASE COURSES

303.02.1 Fine Aggregates Used for Aggregate Sub-Base and Base Courses

Fine aggregate (passing the No. 4 sieve) shall consist of natural sand and/or crushed sand and shall be of such gradation that when combined with other required aggregate fraction in proper proportions, the resultant mixture will meet the gradation specified.

The fine aggregate shall be clean and free from organic matter, clay lumps and other extraneous or detrimental materials.

The fine aggregate shall contain a maximum of 5% clay content at any stage of construction when tested in the Hydrometer Test in accordance with AASHTO T88.

The ratio of fine aggregates passing the No. 200 (0.075 mm) sieve shall not exceed 1/2of the portion passing the No. 40 sieve.

The material passing the No. 40 (0.425 mm) sieve shall have a maximum liquid limit of 25 and the plasticity index shall not exceed 6,when tested in accordance with AASHTO T 89 and T 90.

Where the proposed fine aggregate does not meet the above requirements, the Contractor may, with the Engineer's approval, add additional fine aggregate and/or filler to correct the gradation or to change the characteristics of the material passing the No. 40 sieve so as to meet the Specifications. Such additional material shall be added in a manner approved by the Engineer, which ensures a completely homogeneous material.

303.02.2 Coarse Aggregates Used for Aggregate Sub-Base and Base Courses

Coarse aggregate (retained on the No. 4 sieve) shall consist of crushed stone, crushed gravel or natural gravel and shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation specified.

When crushed aggregate is used for Aggregate Base Course, not less than 90% by weight of the particles on the No. 4 sieve shall have at least one fractured face. The Flakiness Index of the crushed aggregate shall not exceed 35%.

The percentage of wear of coarse aggregate shall not exceed 40% when tested for resistance to abrasion (ASSHTO T96).

The coarse aggregate shall be hard and durable and free from dirt, organic matter, clay and other extraneous or detrimental materials. It shall contain no more than 8% of elongated, soft or disintegrated pieces.

Coarse aggregate shall be subject to sodium sulphate and magnesium sulphate soundness loss tests (AASHTO T104). The maximum allowable sodium sulphate and magnesium sulphate soundness loss shall be 12% and 18% respectively after 5 cycles.

The granular material shall have a 4-day soaked CBR of not less than 30% (for sub-base) and 80% (for base course) when compacted at 100% of modified proctor AASHTO (T 180-D) and tested in accordance with AASHTO T 193.

The granular material shall not contain Gypsum more than 3% (for sub-base) and 2% (for base course). .

The granular material shall have a minimum Sand Equivalent value of 28 (for sub-base) and 31(for base course), when tested in accordance with ASTM D2419.

The maximum permitted swell for the granular material used in the sub-base courses shall be 1.0%(for sub-base) and 0.5%(for base course), when tested in accordance with ASTM D4829.

303.02.3 Types of Aggregate Sub-Base and Base Courses

The combined gradation including fine and coarse aggregates shall conform to the gradation of Type (A) or (B) or (C) in Table 303.02.3a for aggregate subbase and Table 303.02.3b for aggregate base course.

The continuous smooth gradation of materials used shall be kept within the specified gradation limits and gap gradation must be avoided. Selection of one of the gradations shown in the above table shall be as shown on the Drawings and/or Specifications. Gradation A or B shall be used when crushed aggregate base and sub-base is specified.

No. of Sieve Size	Gradation A	Gradation B	Gradation C
63 mm (2 ½ in)	-	-	-
50 mm (2 in)	-	-	100
37.5 mm (1 ½ in)	-	100	70-100
25 mm (1 in)	100	70-100	55-85
19 mm (¾ in)	70-100	60-90	50-80
9.5 mm (3/8 in)	50-80	45-75	40-70
4.75 mm (No. 4)	35-65	30-60	30-60
2.00 mm (No. 10)	25-50	20-50	20-50
0.425 mm (No. 40)	15-30	10-30	10-30
0.075 mm (No. 200)	5-15	5-15	5-15

Table 303.02.3a Gradation Limits for Aggregate Sub-base Course by Class

No. of Sieve Size	Per cent by weight passing		
	Gradation A	Gradation B	Gradation C
63 mm (2 ½ in)	100	-	-
50 mm (2 in)	90 - 100	-	-
37.5 mm (1 ½ in)	60 - 90	100	-
25 mm (1 in)	42 - 77	60 - 100	100
19 mm (¾ in)	35 - 70	55 - 85	80 - 100
12.5 mm (½ in)	25 - 60	-	-
4.75 mm (No. 4)	15 - 40	35 - 60	30 - 60
2.00 mm (No. 10)	10 - 25	25 - 50	20 - 45
0.425 mm (No. 40)	5 - 15	15 - 30	-
0.075 mm (No. 200)	2 - 9	8 - 15	3 - 10

Table 303.02.3b. Gradation Limits for Aggregate Base-Course material by Class

303.03 CONSTRUCTION REQUIREMENTS FOR AGGREGATE SUB-BASE AND BASE COURSES

303.03.1 Finished Subgrade Levels

Prior to commencing the construction of the sub-base and base courses, it is necessary to make sure that the subgrade conforms to the Specifications and is compacted to the Maximum Dry Density as indicated in Section 2 (Earthworks) of these Specifications, and that the surface thereof conforms to the levels and slopes indicated in the Drawings. In all cases the approval of the Engineer must be obtained before commencing spreading of material for the sub-base and base courses.

303.03.2 Screening and Mixing of the Materials

Screening shall be required for the materials used in aggregate sub-base and base courses. Screens shall be of the size and number required to remove oversize aggregate and, if necessary, to separate the materials into two or more fractions so that they may be combined to meet the required gradation. When conveyor belt samples from the end of the screening and/or crushing-screening operation yield a product consistently within the specified gradation, no further mixing shall be required and the material may be loaded and hauled directly to the road. If stockpiled, it shall be stockpiled so as to prevent segregation.

Mixing of material can be achieved through the use of the central mixing plant or travel mixer as per Clause 302.01 of these Specifications. Where separate size materials are to be blended to meet the gradation, such blending shall be as directed by the Engineer and shall be accomplished prior to delivery to the roadway. Mixing of separate materials on the roadway by motor grader will not be permitted.

303.03.3 Spreading and Compacting

After carrying out the screening and mixing of aggregate material, samples of the approved material shall be taken in order to determine the Optimum Moisture Content.

Material shall then be spread on the road surface to thickness that would result in layers not more than 150 mm thick after compaction.

The natural moisture content of materials constituting the sub-base and base courses shall be determined. If the natural moisture content is less than the optimum moisture content, the necessary amount of water must be added to obtain the optimum content, allowing for the quantity which may be lost by evaporation in the process of raking, leveling and compacting, depending on atmospheric temperature, quantity of material and the equipment and plant to be used in this operation. The layer shall be compacted when the moisture content therein is within $\pm$2% of the optimum moisture content in order to obtain Maximum Dry Density, and the moisture content is uniform in all parts of the section where the work is being carried out and in the various depths of the layer thickness.

Compaction shall start immediately thereafter, by means of pneumatic and steel rollers or vibratory rollers and in accordance with the instructions of the Engineer.

Compaction must start with rollers from extreme sides proceeding gradually toward the road axis. Rolling shall continue until the entire thickness of each sub-base or base course layer is thoroughly and uniformly compacted to 100% AASHTO T 180 (Method D) maximum density. Final rolling of the completed course shall be by means of an approved self-propelled roller. Rolling shall be accompanied by sufficient blading, to insure a smooth surface, free from ruts or ridges and having the proper shape. When additional water is required, it shall be applied in an approved manner.

303.03.4 Multi-Layers

During all the above-mentioned operations of mixing, spreading, compacting and leveling of sub-base and base courses material, care must be taken so that layers already compacted under the layer being executed are not affected, or that the finished sub-grade or base surface is also not affected. This aspect must be given special attention in places where equipment makes turns in going back and forth and any such damage resulting in mixing the various layers constituting the different sub-grades and base courses shall be carefully made good by the Contractor at his expense and to the satisfaction of the Engineer.

If more than one sub-base or base course is required for reaching the required thickness indicated on the Drawings or described in the Specifications, each such course will be constructed as hereinbefore described.

Where the finished compacted thickness exceeds 150mm placing shall be executed in composite layers each layer not exceeding 150mm in compacted thickness as directed by the Engineer.

303.03.5 Protection of Surface

The Contractor shall protect the sub-base or base course so that it shall be maintained sound during work progress, after its completion and prior to receiving the bituminous layers or prior to laying the surface overlay thereon. Any damage caused to the layer if exposed to traffic or natural conditions resulting in damage of its surface should be made good at the expense of the Contractor and to the satisfaction of the Engineer.

The sub-base and base courses shall not be rolled when the underlying material is soft or yielding or when the rolling causes a wave-like motion in this course.

When the rolling develops irregularities, the irregular surface shall be loosened, then refilled with the same kind of material as used in constructing the course and again rolled according to Specifications. Along places inaccessible to rollers, the sub-base and base courses' material shall be tamped thoroughly with mechanical tampers.

Work on the sub-base and base course shall not be permitted during rainy weather.

Hauling equipment may be routed over completed portion of the sub-base and base courses provided no damage results and provided that such equipment is routed over the full width of the course to avoid rutting or uneven compaction.

The Engineer has the right to stop all hauling over completed or partially completed sub-base and base courses when in his opinion such hauling is causing damage.

303.03.6 Preparing the Surface before Priming

Following the completion of the base course and sub-base courses the Contractor shall perform all maintenance work necessary to keep the course in a condition for priming. The prime coat shall be applied after preparation of the previously compacted surface, all in accordance with Clause 405 of Section 4 (Asphalt Works) of these Specifications.

303.03.7 Testing and Acceptance of Aggregate Sub-base and Base Courses

Prior to the application of any prime coat or any other paving course, the aggregate sub-base and/or base course shall have been tested and accepted by the Engineer. The following shall be adhered to in accepting completed aggregate sub-base and base courses:

A. Strength Specification for Compacted Aggregate Sub-Base and Base Courses

The aggregate sub-base and base courses shall be compacted and tested for acceptance in accordance with the compaction requirements of Clause 303.03.3 of these Specifications.

In addition, the sub-base and base courses shall be tested for the degree and uniformity of stiffness by measuring the in-situ deflections. The test method will be a measurement of dynamic deflection using the Dynaflect equipment.

The results of Dynaflect testing shall be considered a measure of conformance to specification requirements for aggregate sub-base and base courses.

Dynaflect testing shall be performed on permanent works and on Type IV – Long Term Detours.

The deflection limits for Dynaflect testing shall be as shown in Table 303.03.7.

	Depth of fill, mm	Wl limits – mill inches
Aggregate Sub-Base or Base (150 mm thick) on cut or fill layers	0 150 300 450 600 750 900 1000 or more	1.40 1.34 1.28 1.26 1.24 1.22 1.20 1.20
Aggregate Sub-base or Base (300 mm thick) on cut or fill layers	0 150 300 450 600 750 900 1000 or more	1.06 1.02 1.00 0.98 0.98 0.96 0.96 0.94

Table 303.03.7 Deflection Limits for Dynaflect Testing

Dynaflect testing shall be performed longitudinally across the full width of the sub-base or base course. Testing will be at maximum intervals of 25 metres and representing a maximum width of 4 metres.

A minimum of 5 tests shall be made on every strip tested.

The Contractor shall be notified by the Engineer that the tested layer is accepted or rejected within 24 hours, excluding Fridays and Kuwait holidays, following the time the Dynaflect test was performed by the Contractor under the Engineer's supervision, and the results were handed over to the Engineer.

Where Dynaflect test results fail to meet minimum deflection requirements, the Contractor shall at his expense rework, recompact or if necessary remove and replace the work as required to produce satisfactory test results.

In the event that Dynaflect testing of a layer is not possible, the work may be accepted at the discretion of the Engineer on the basis of satisfactory density results. In such cases, however, the subsequent layer shall only be accepted on the basis of Dynaflect tests.

B. Requirements for Compaction

Wherever the degree of compaction is found to be less than the 100% specified, the area of sub-base or base course involved shall be satisfactorily corrected so that the specified density is achieved. One field density test shall be done for every 500 m^3 of every layer or whenever materials changed, whichever is less.

C. Requirements for Gradation

Wherever the gradation is found to be outside the limits specified, the area of sub-base and/or base course involved shall be scarified, removed or otherwise reworked as directed by the Engineer to provide a material

within specification limits. One gradation test shall be done for every 700 cu.m of every layer or whenever materials changed, whichever is less.

D. Requirements for Thickness

Wherever the thickness of compacted aggregate sub-base or base course is found to vary from the plan thickness by more than 10% the area involved shall be satisfactorily corrected to provide the required thickness constructed to the specified grade level. Thickness shall be measured for every 2000 sq.m and for every layer.

E. Requirements for Evenness of Surface and Grade Levels

The final surfaces of the sub-base or base course shall be tested by means of a 4 metre long straight edge, and no rises or depressions in excess of 10 mm shall appear in the surface. Likewise the finished surface shall be constructed to the specified grade levels with a tolerance of +5 mm or -10mm. The minus tolerance shall be compensated by the subsequent layer.

Where these requirements are not met, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the course by scarifying to a minimum depth of 75 mm or 4 times the maximum particle size, whichever is the greater, reshaping by adding or removing material as necessary and recompacting in accordance with the Specifications.

The elevations of the finished sub-base and base course shall be checked by the Contractor in the presence of the Engineer at intervals of 20m on straight lines and of 10 m on curves, and at intermediate points as directed.

F. Testing Frequency

Sub-Base and Base course material shall be tested in accordance with Table 303.03.8 after mixing with water at the mixing plant or in-situ compaction and if satisfactory shall be approved for use.

303.04 MEASUREMENT AND PAYMENT OF THE AGGREGATE SUBBASE AND BASE COURSES

303.04.1 Measurement

Measurement of aggregate sub-base and base courses shall be by meter square of the specified thickness laid and compacted in place for the various types required in accordance with the Drawings, Specifications or as directed by the Engineer and shall be calculated from the top surface area, excluding tapered edges which shall be included in the rate.

No measurement shall be made for direct payment of overdepth construction, regardless of the Engineer's permission for it to remain in place.

303.04.2 Payment

Payment shall be made at the rate indicated in the Bills of Quantities which rate shall include for, but not by way of limitation, all labour, tools, plant, materials, transport, mixing, screening, spreading, rolling and compaction, shaping and levelling, testing, etc. and for everything necessary for the proper completion of the work in accordance with the Drawings, Specifications and instructions of the Engineer.

Where new road construction work adjoins or meets existing road construction, e.g. new shoulders and cross-roads, no separate payment will be made for cutting back the edges of the existing construction to receive new sub-base or base layers, the cost being deemed to be included with the cost of the new sub-base or base courses.

303.04.3 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
303.1	Aggregate Sub-Base course (Type, Thickness)	sq.m
303.2	Aggregate Base Course (Type, Thickness)	sq.m

Source of Materials		Control on Site (The Road)	
Required Tests (A)	**Repetition Required for all Tests in (A)**	**Required Tests (B)**	**Repetition Required for all Tests in (B)**
1. Gradation of Materials	Minimum one test for each source	1. Modified compaction test	Minimum one test for every 700 cu.m. of every layer, or whenever Materials changed, whichever is less
2. Plasticity Index	"		"
3. Abrasion	"		"
4. C.B.R.	"		"
5. Sand equivalent	"		"
6. Percentage of fractured Grains	"	2. Gradation of Materials	"
7. Thin and elongated pieces	"	3. Plasticity Index	"
		4. C.B.R.	"
		5. Abrasion	
		6. Sand equivalent	"
		7. Clay lumps & friable particles	
		8. Field Density	One test shall be done for every 500 cu.m of every layer or whenever materials changed, whichever is less.
		9. Thickness	Test for every 2000 sq.m. and for every layer

Table 303.03.8: Required Tests and Minimum Repetition for Base and Sub-Base Course Materials

304 - SAND ASPHALT SUB-BASE AND BASE COURSES

304.01 DESCRIPTION

The Sand-Asphalt sub-base and base courses shall be composed basically of mineral aggregates, mineral filler and bitumen combined in an asphalt mixing plant. Several mineral aggregates may be sized and combined in such proportions that the resulting blend is well-graded and is within the specified gradation requirements. The incorporation of mineral filler and/or other ingredients shall be in such amounts as found appropriate to meet the required criteria for test limits as herein specified and as instructed by the Engineer. This shall be taken into consideration by the Contractor when fixing his rates and no additional compensation shall be made for changes of mix design necessary to meet the specification requirements.

304.02 MATERIALS REQUIREMENTS FOR SAND-ASPHALT SUB-BASE AND BASE COURSES

304.02.1 Materials

The materials used in Sand-Asphalt sub-base and base courses shall meet the requirements given in Section 4 (Asphalt Works) of these Specifications as follows:

Fine Aggregate	Clause 402.01
Coarse Aggregate	Clause 402.02
Commercial Mineral Filler	Clause 402.03
Asphalt Cement	Clause 402.04
Hydrated Lime	Clause 402.07

304.02.2 Types of Sand Asphalt

The types of Sand-Asphalt shall be as designated on the Drawings or in the Bills of Quantities and shall conform to the compositions as described herein and as shown in Table 304.02.2.

Sieve Size	Percent Passing by Weight		
	Type A	Type B	Type C
19mm (¾ in)	100		100
9.5mm (3/8 in)	95-100	100	95-100
4.75mm (No. 4)	85-100	85-100	85-100
2.36mm (No. 8)	58-100	70-85	58-100
600µ (No. 30)	22-74	38-56	22-74
300µ (No. 50)	10-50 6-	27-43	10-50
75µ (No. 200)	12	4-12	4-12
Asphalt Cement % by weight of total aggregate	4.0 - 7.0	5.0 - 8.0	5.0 - 8.0

Table 304.02.2 Composition of Sand-Asphalt Mixes Including Hydrated Lime and Commercial Mineral Filler where required.

A. Sand-Asphalt (Type A)

Shall consist of a blend of natural and crushed mineral aggregates, hydrated lime (if used), commercial mineral filler and bitumen combined to meet the Specification requirements, and shall be constructed to the thickness as indicated on the Drawings and in the Specifications. A minimum of 1.5% hydrated lime (if used) and a minimum of 4.0% mineral filler by weight of total mineral aggregates shall be added in accordance with Clause 403.02.2c of Section 4 (Asphalt Works) of these Specifications. The aggregate blend shall contain a minimum of 25% crushed material.

B. Sand Asphalt (Type B)

Shall consist of crushed coarse aggregate, natural and/or crushed fine aggregate, hydrated lime (if used), commercial mineral filler and bitumen combined to meet the Specification requirements and shall be constructed to the thickness as indicated on the Drawings and in the Specifications.

A minimum of 1.5% hydrated lime (if used) by weight of total aggregate shall be added in accordance with Clause 403.02.2c of Section 4 (Asphalt Works) of these Specifications. The aggregate portion shall consist of a minimum of 25% crushed material.

C. Sand Asphalt (Type C)

Shall consist of natural or crushed mineral aggregates, commercial mineral filler and bitumen combined to meet the Specification requirements and shall be constructed to the thickness as indicated on the Drawings and in these Specifications.

Commercial mineral filler shall be used in all Types of Sand-Asphalt Mixes as necessary to meet gradation and

design criteria. Aggregates shall be well graded within the above limits. The Engineer reserves the right to require modifications or rejections of proposed compositions which have maximum percentages passing some sieves and minimum passing others. The minimum quantity of hydrated lime (if used) specified for Type A and Type B Sand-Asphalt shall be increased as necessary to meet the design criteria.

304.02.3 Design Criteria

Laboratory test specimens of the Sand Asphalt Mix shall be prepared and tested in accordance with the procedures set forth for the Marshall Method of mix design. Mix designs shall be checked and approved by the Engineer prior to use.

Marshall stability tests shall be conducted on trial mixes in order to determine the optimum asphalt cement content within the specified range. The asphalt cement content thus determined shall be used in the Job Mix Formula in accordance with Clause 304.02.4 of these Specifications.

The laboratory trial mixes, after being air cured for a period of 7 days and tested in accordance with AASHTO T167, shall have a minimum compressive strength at 25 degrees C, of 20 kg/cm^2

Test requirements and criteria for Sand Asphalt Mixes prepared under these Specifications shall be as indicated in Table 304.02.3:

Test	Type A		Type B		Type C	
	Min.	Max.	Min.	Max.	Min.	Max.
Marshall Specimens (AASHTO T 245) Number of Compaction blows, each end of specimen	50		50		50	
Stability at 60° C, kg	300		175		300	
Flow, 0.25 mm (0.01 inch)	8	20	8	20	8	20
Air Voids, %	4	18	3	18	4	18
Immersion Compression Specimens (AASHTO T165) Index of Retained Strength	50		60		No Requirement	

Table 304.02.3 Design Criteria for Sand-Asphalt

Mechanically operated compaction equipment is to be used in the Marshall design procedures. The indicated number of blows is for units which rotate the specimens during compaction. Additional blows giving equivalent results are required for compaction units having stationary bases which do not rotate the specimens during compaction.

304.02.4 Job Mix Formula and Allowable Tolerances

All the provisions of Clause 404.02.4 of Section 4 (Asphalt Works) of these Specifications shall form part of this Clause except as specified herein for the maximum permissible ranges of tolerances:

- Passing sieves No.4 (4.75 mm) and larger $\pm$ 5.0%
- Passing sieves No.8 (2.36 mm), 30 (0.600 mm) and 50 (0.300 mm) $\pm$ 7.0%
- Passing sieves No.200 (0.075 mm) $\pm$ 2.0%
- Asphaltic cement $\pm$ 0.4%
- Temperature of mix when emptied from mixer + 10º C

304.02.5 Sampling and Testing of Sand Asphalt

Sampling and testing of Sand-Asphalt shall be in accordance with the procedures set forth in Clause 404.02.5 of Section 4 (Asphalt Works) of these Specifications for sampling and testing Asphaltic Concrete Mixes.

304.03 CONSTRUCTION REQUIREMENTS FOR SAND ASPHALT

304.03.1 General Requirements

All of the provisions of Clause 404 of Section 4 (Asphalt Works) of these Specifications in respect of Specifications for Construction Requirements for Asphaltic Concrete shall be adhered to with respect to Sand-Asphalt subject to the following modifications and additions.

304.03.2 Preparation and Handling of Mineral Aggregate

The moisture content of the heated and dried aggregate shall not exceed 1.0%. If the Engineer so requires, the angle of the drier shall be reduced to such a position as to hold material in the drier for a longer period of time for optimum condition of heating and drying.

304.03.3 Proportioning and Mixing

The heated ingredients shall be combined in such a manner as to produce a mixture which when emptied from the mixer, shall have a temperature in accordance with Clause 404.03.4 of Section 4 (Asphalt Works) of these Specifications. The temperature of the aggregate immediately prior to mixing shall be within $\pm 10^{o}C$ of the temperature of the asphalt cement and the temperature of the aggregate and asphalt prior to mixing shall be approximately that of the completed mix as defined in the Job Mix Formula approved by the Engineer. The mix temperature shall be within the allowable tolerance set out in the Job Mix Formula when emptied from the mixer.

Filler shall be proportioned into the mixer with the aggregate in the quantities specified in the Job Mix Formula, all as directed by the Engineer.

304.03.4 Delivery of the Mix

The mix shall be delivered to the asphalt paver at a temperature within $14^{o}C$ of the Job Mix Formula temperature.

304.03.5 Spreading of the Mix

The Sand-Asphalt sub-base and base courses shall be laid in layers of 100 mm maximum compacted thickness. Thinner layers shall be used if excessive shoving, etc. occurs. Overlying layers shall be placed as soon as practicable after the first layer has been executed to the required grade, line, cross-section and density finished, rolled and cooled and after the tack coat, if required, has been applied in accordance with these Specifications.

304.03.6 Compaction of the Mix

The initial breakdown rolling shall start at the highest temperature possible whilst avoiding an undue amount of cracking and/or shoving. In all cases it shall start before the mixture cools below $75^{o}C$

Tapered edges against which the additional layer is to be placed, shall be carefully rolled along the entire length of the edges.

Heavy equipment or rollers shall not be permitted to stand on the finished surface before it has been compacted and has thoroughly cooled.

304.03.7 Testing and Acceptance of Completed Sand Asphalt

All of the provisions of Clause 404 of Section 4 (Asphalt Works) of these Specifications shall be applicable to Sand Asphalt subject to the modifications and additions included herein.

A. <u>Requirements for Compaction of Sand Asphalt</u>

The minimum degree of compaction for Sand Asphalt Mixes shall be 96% of the Laboratory Marshall Specimens prepared in accordance with the Job Mix Formula.

B. <u>Thickness Requirements</u>

The total constructed thickness of the sand asphalt sub-base and base used for new construction, reconstruction or widening shall not vary by more than 10% from the total specified thickness. But if the total constructed

thickness of the Sand-Asphalt course is less than the total specified thickness by a value more than 10% and less than 15%, then the shortage shall be made good by the Contractor as directed by the Engineer. If, however, the total constructed thickness of the Sand-Asphalt sub-base or base is less than the total specified thickness by a value more than 15%, then the work shall be considered rejected and on this basis the inserted price of the Sand-Asphalt course shall be deducted until the base has been removed and the sub-grade made good at the Contractor's expense and a new course has been laid in accordance with the Specifications.

At the request of the Contractor, the Engineer, if he so elects, may accept areas deficient in the thickness by more than 15% if the deficiency is made up by constructing increased thickness of asphalt layers on top of the Sand-Asphalt.

C. Requirements for Levels and Evenness of Surface

Variations in levels of the base after construction of the sub-base and base shall not exceed 10mm from the levels specified on the Drawings.

When tested by a four-meter straightedge placed at right angles and parallel to the road centerline, or when tested by a crown template placed centrally at right angles to the road centerline the maximum gap between the surfaces of the sub-base or base and the testing edge shall not exceed 10mm.

304.04 MEASUREMENT AND PAYMENT FOR SAND ASPHALT

304.04.1 Measurement

Measurement of sand asphalt courses shall be by meter square for the various types and thickness required in accordance with the Drawings, Specifications or as directed by the Engineer and shall be calculated from the top surface area, excluding tapered edges which shall be included in the rate.

304.04.2 Payment

Payment shall be made for this work at the rate inserted in the Bills of Quantities, and the rate shall include for, but not by way of limitation, supplying and spreading the mixture, thoroughly mixing and compacting each layer to reach the necessary dry density, compacting and adjusting the finished surface to the proposed levels and grades all according with these Specifications, the Drawings and to the instructions of the Engineer.

Where new road construction adjoins or meets existing road construction, e.g. new shoulders and cross-roads, no separate payment shall be made for cutting back edges of the existing construction to receive the new sub-base or base layers, the cost being deemed to be included within the cost of the new sub-base or base course.

304.04.3 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
304.1	Sand asphalt sub-base course (Type, Thickness)	sq.m
304.2	Sand asphalt base course (Type, Thickness)	sq.m

305 - CEMENT STABILIZED BASE COURSE

305.01 DESCRIPTION

These works shall consist of furnishing, mixing, spreading, compacting and finishing courses composed of sand, sandy gravel or similar soil, stabilized with cement as appropriate, as and where shown on the Drawings.

305.02 MATERIALS

305.02.1 Soil for Cement stabilization

Sand and gravel soils shall have the following particle size distribution given in Table 305.02.1.

AASHTO Sieve	% passing (by mass)
50 mm (2 in)	100
4.75 mm (No. 4)	50 - 100
1.80 mm (No. 12)	37 - 80
425 µm (No. 40)	15 - 50
75 µm (No. 200)	0 - 20
2 µm	0 - 3

Table 305.02.1. Soil for Cement Stabilization

The mix-in-place method of construction shall be used only on sites with naturally occurring sand and gravel mixture. For the central plant method of construction, the materials shall be selected by the Contractor from other sources complying with the requirements of this Clause and shall be subject to the approval of the Engineer.

305.02.2 Cement as Stabilizing Agent

The cement to be used for stabilization shall be Ordinary Portland cement or Sulphate Resisting cement, as shown on the Drawings, or as instructed by the Engineer. Portland cement shall conform to the requirements of BS12 Part 2 or AASHTO M85 Type I for ordinary and rapid hardening types, and BS4027 Part 2 or AASHTO M85 Type V for Sulphate Resisting Cement.

At least two silos shall be used for cement storage. Before recharging a silo it shall be emptied completely and cleaned out. During the time of charging a silo shall not be used for batching.

The stored cement shall be free-flowing and free of lumps. Cement shall not be stored for longer than 4 months. Cement that has remained in store for a period greater than 4 months, or of which there is doubt as to quality shall be re-tested by standard mortar tests to determine whether it still meets the requirements of the Standards.

Curing seal shall consist of approved proprietary curing compound, or MC-70 cutback bitumen to prime coat standard as specified in Section 4 (Asphalt Works) of these Specifications.

305.02.3 Water

The water shall be clean and free from impurities, oil, acid, salts, alkali, organic matter, and other potentially deleterious substances. Water from doubtful sources shall not be used until tested in accordance with AASHTO T26 and approved. Additionally the total salt content of the cement stabilized base course mixture shall meet the following requirements: The total chloride content (sum of both acid soluble and water soluble chlorides) expressed as chloride ion, when tested in accordance with BS 1881, shall not exceed 0.10 percent by weight of dry cement. The total sulfate content expressed as SO_3, when tested in accordance with BS 1881, shall not exceed 3 percent by weight of dry cement.

305.02.4 Mix Design

Before starting the work of stabilization, soil-cement trial mixes shall be carried out. The proposed mix design shall be submitted by the Contractor for approval by the Engineer. It shall show the percentage of cement and water to be used with the naturally occurring soil so as to obtain a stabilized mixture with the following properties:

- The minimum cube compressive strength shall be 5.0 N/mm2 after molding and storage at a minimum humidity of 95% for a period of 7 days. The molding shall be in accordance with AASHTO T134 and the strength testing shall be in accordance with BS 1881. The cement content of trial mixes shall be adjusted until this strength is achieved.
- The maximum volume change (swelling) shall be 2% and the maximum loss in weight shall be not more than 8%, when cylinders are molded and tested in accordance with AASHTO T 135, Method B.
- Cement content and water content of the mix on the Site shall each be within - 0.2% to +2% of the approved mix design.

305.03 CONSTRUCTION REQUIREMENTS

305.03.1 Surface Preparation

Prior to placing of stabilized base on subgrade, the subgrade shall have been properly completed and approved as specified in Clause 206 of Section 2 (Earthworks) of these Specifications.

305.03.2 Construction of Trial Section

If the Engineer requires it, before commencement of site stabilization works and after completion of laboratory mix design, the Contractor shall lay a trial section of stabilized material 2 lanes wide by 50m long, at an approved location on or near to the Site.

This trial section shall be laid using the same materials, mix proportions, mixing, spreading and compaction equipment, and construction procedures that are proposed for use in the Works.

The trial section shall serve as a field verification of the laboratory mix design. The results of the dry density and moisture content measurements made in the trial section will be used in association with the laboratory tests to establish the moisture content and minimum percent compaction to be attained in the site stabilization works.

The trial section shall also demonstrate the adequacy of mixing, spreading and compaction equipment and the suitability of the methods and organization proposed.

305.03.3 Cement Stabilization Procedures - Plant Mixing

When cement and granular material are to be mixed in a stationary plant, the plant shall be an approved type pugmill mixing plant of either the batch mix type with revolving blade or rotary drum, or the continuous mixing type. Proportioning of materials and of water may be by either weight or volume.

Cement shall be added in such a manner that it is uniformly distributed during the mixing operation. Safe, convenient facilities shall be provided for sampling cement in the supply line to the weigh hopper or pugmill.

Means shall be provided whereby the Engineer may verify the amount of water per batch or the rate of flow for continuous mixing. The time of the addition of water and the points at which it is introduced into the mixer shall be as approved.

The charge in a batch mixer, or the rate of feed to a continuous mixer, shall not exceed that which will permit complete mixing of all of the material. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected.

The moisture content of the completed mixture shall be not more than one percent below optimum moisture content at the point of delivery to the Works.

305.03.4 Cement Stabilization Procedures - Batch Mixing

Batch mixing plants shall be equipped with a sufficient number of paddles of a type and arrangement to produce a uniformly mixed batch.

The mixer platform shall be of ample size to provide safe and convenient access to the mixer and other equipment.

The mixer shall be equipped with a timing device which will indicate by a definite audible or visual signal the expiration of the mixing period. The device shall be accurate to within 2 seconds.

The time of mixing a batch shall begin after all ingredients are in the mixer and shall end when the mixer is half emptied. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly coated materials of uniform appearance is produced. The time of mixing shall not be less than 30 seconds. When blending of different sizes is required, the materials shall be blended as they enter the mixer.

Cement for each batch shall be weighed on scales separate from the aggregate batching scales. Each cement scale graduation shall be approximately 0.001 times the total capacity of the scales. The total capacity shall not be greater than that of commercially available scales when weighing twice the amount of cement required when the plant is operated at full capacity. No scale shall be used with a capacity less than 500 kg.

305.03.5 Cement Stabilization Procedures - Continuous Mixing

Continuous mixing plants shall be designed such that granular materials are drawn from the storage facility by feeders which continuously supply the correct amount of granular material in proportion to the cement and so arranged that the proportion of each size can be separately adjusted if more than one size is used. Storage facilities containing fine material shall be equipped with vibrating units which shall vibrate the side walls of the feeder to prevent any hang-up of materials while the plant is operating**.**

A control system shall be provided that will automatically close down the plant when the material in any storage facility approaches the strike-off capacity of the feed gate. The plant will not be permitted to operate unless the control system is in proper working order.

The feeder for the granular material shall be mechanically or electrically driven. Mechanically driven feeders shall be directly connected with the drive on the cement feeder. The drive shaft on the feeder shall be equipped with a revolution counter reading to 0.1 of a revolution. Electrically driven feeders shall be actuated from the same circuit that services the motor driving the cement feeder.

The cement feeder and the granular material feeders shall be equipped with devices by which the rate of feed can be determined while the plant is in full operation.

305.03.6 Cement Stabilization Procedures - Mixed in Place Procedures

Mixed in place procedures will normally be permitted when the granular material to be stabilized is in-situ Site material.

Plant and equipment for pulverizing (if required) and for mixing all materials will be approved on the basis of preliminary trials to establish that such plant and equipment are capable of producing the specified degree of mixing and uniformity of stabilized material for the full thickness of each layer. Single pass or multi-pass equipment may be used.

The mixing equipment shall be equipped with a device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times. Cement shall be spread ahead of the mixer by means of a cement spreader, fitted with a device to ensure a uniform and controllable rate of spread of cement transversely and longitudinally.

If multi-pass equipment is utilized, the fine cohesive fraction (if any) of the material shall first be pulverized to the required depth with successive passes and the moisture content adjusted if it is more than 3% below the value required for compaction. Cement shall then be spread and mixing continued with successive passes until the required depth and uniformity have been achieved.

If it is necessary to adjust the moisture content of the material to the optimum for compaction, water shall be added during the mixing operation using a water sprayer of such design that the water is added in a uniform and controllable manner both transversely and longitudinally.

The mixing equipment shall be set so that it cuts slightly into the edge of any adjoining completed lane so as to ensure that all material forming the layer has been properly processed. The Engineer may approve the use of scarifiers or preparizers ahead of the mixing equipment. The output of the mixing equipment shall be such that a minimum rate of 20 lin.m./hr measured longitudinally of completed stabilized layer can be maintained in order to permit satisfactory compaction of the mix.

305.03.7 Cement Stabilization Procedures - Placing of Stationary Plant Mixes

Immediately prior to depositing the mix, the surface area to be covered shall be moistened and kept moist.

The cement stabilized mix shall be protected against moisture loss during transporting, by use of suitable covers. The mix shall be deposited on the roadbed at a quantity per lin.m. which shall provide the compacted thickness for the width being spread without resort to spotting, picking up, or otherwise shifting the mixture. Segregation shall be prevented and the mix shall be free from pockets of coarse or fine materials.

The mix shall be spread in widths of not less than 2 lanes, insofar as the width of surface permits. Longitudinal construction joints shall fall within 300 mm of lane lines. The mix shall be spread by one or more spreaders operating in a staggered position across the subgrade. If traffic conditions require that less than 2 lanes be

spread, not more than 2 hours shall elapse between the times of placing the material in adjacent lanes.

The compacted thickness of any one layer shall not exceed 200 mm and shall be not less than 80 mm. When more than one layer is placed, the surface of the lower layer of compacted mix shall, until covered with the next layer, be kept moist with water or a curing seal as specified.

In the case of areas inaccessible to mechanical spreading equipment, the mix may be spread in one layer by approved methods only. After spreading, the material shall be thoroughly compacted to the required lines, grades, and cross section by means of pneumatic tampers, or other approved compacting equipment.

Use of motor graders will not be permitted during spreading or compacting operations. Motor graders may be used only to trim the edges and surface after compaction in order to finish within the specified tolerances.

A motor grader may be classified as a self-propelled mechanical spreader if it has been equipped with end wings on the blade, has the blade locked in a position perpendicular to the direction of travel, and is equipped with cross slope and automatic grade controls that meet the requirements for the specified type of spreading.

Each layer of the mix shall be spread in one operation with an approved type self-propelled mechanical spreader such that the layer is made ready for compaction without further shaping. The spreader shall be provided with a fully automatic and adjustable screed that strikes off and distributes the material to the full width being spread and to the surface tolerances specified.

The spreader shall be equipped with grade sensing controls to automatically control the longitudinal grade and transverse slopes of the screed. Screed action includes any cutting, crowding, or otherwise that produces a finished surface texture of uniform appearance.

Cement stabilized mixes shall not be mixed or placed while the atmospheric temperature is below 2 degrees C. A curing seal as specified shall be applied to the surface of the compacted mix before the atmospheric temperature approaches 2 degrees C.

305.03.8 Cement Stabilization Procedures - Compaction and Finishing

Immediately upon completion of spreading or spreading and mixing in place operations, and completion of shaping, the mix shall be initially compacted by one complete coverage using approved type rollers.

If the finished surface after initial compaction is outside the specified tolerance, all high spots shall be trimmed off to within the specified tolerance. Filling of low areas by drifting or hauling of trimmed material will not be permitted.

Following trimming, the finished surface shall be finally compacted to not less than 100% of the laboratory density of the approved job mix specimens as determined by AASHTO T 134. Final compaction shall be accomplished in such a manner that no loose material remains on the surface and all tear marks are eliminated.

The surface tolerances shall conform with the tolerance requirements for aggregate base. In the case of any areas which are lower than the allowable tolerance, the stabilized layer shall be removed and fresh stabilized mix placed and properly compacted and finished, unless filling of the low areas with bituminous concrete or cement concrete is approved.

When the superimposed course will be cement concrete, the low areas may, if approved, be filled with concrete at the time and during the same operation that the concrete pavement is placed. Such additional concrete shall be at the Contractor's expense.

When the superimposed course will be bituminous concrete, the low areas may, if approved, be filled with bituminous concrete to the same standard. This filling shall be carried out as a separate operation prior to placing the bituminous concrete course (unless the thickness to be placed is too small to make this practicable) and shall be at the Contractor's expense.

Not more than 2 hours shall elapse between the time water is added to the mixed materials and the time of completion of initial compaction. Final compaction shall be completed within 30 minutes of initial compaction.

At the end of each day's work and when operations are delayed or stopped for more than 2 hours, a vertical construction joint shall be made in the fully compacted layer, perpendicular to the centerline. Additional mix shall not be placed until the construction joint has been approved.

One hour after the stabilized mix has been finally compacted; vertical longitudinal joints shall be constructed by cutting into the existing edge to a depth of approximately 100 mm. The mix cut away shall be discarded. The face of the cut joints shall be moistened in advance of placing the adjacent lane.

305.03.9 Curing of Cement Stabilized Courses

Curing seal as specified shall be applied uniformly to the completed surface at a rate of between 0.5 and 1.2 kg./sq.m., or as determined by the Engineer. The curing seal shall be applied on the same day that final compaction is performed and as soon as practicable thereafter. The surface shall be kept moist until the seal is applied.

Damage to the curing seal or stabilized surface shall be promptly repaired by the Contractor at his own expense, in an approved manner.

305.03.10 Testing of Cement Stabilized Courses

For every 5,000 sq.m. of each stabilized layer or for each day's completed area (whichever is smaller) the following sampling and testing shall be carried out:

In situ density of a minimum of 3 samples (taken immediately after final compaction) determined in accordance with AASHTO T 191 and which shall be not less than 100% of the density of the approved laboratory mix.

Cement content in accordance with AASHTO T 211.

Gradation of mix in accordance with AASHTO T 27.

Moisture - density relationship for mix sampled fresh from the Site, in accordance with AASHTO T 134 if the source of the material is changed.

Compressive strength of a set of 3 test specimens molded and cured in accordance with AASHTO T 134 and T 126, and tested in accordance with AASHTO T 22.

305.04 MEASUREMENT AND PAYMENT OF THE STABILIZED BASE COURSES

305.04.1 Method of Measurement

Cement Stabilized Course, shall be measured by meter square of the specified thickness of compacted mix transported, furnished, premixed and placed, or mixed in place, compacted, trimmed, jointed, cured, completed and accepted including all trial sections within the road limits. Measurements shall be of the area and thickness dimensions shown on the Drawings.

If the trial section is ordered by the Engineer to be constructed outside the road alignment, it shall not be measured for direct payment, but it shall be considered as subsidiary works the costs of which will be deemed to be included in the Contract prices for Pay Items. The removal and reinstatement of the area under this trial section shall also be considered as subsidiary works.

Curing seal shall be measured by sq.m. of areas computed from the length and width of the completed sections shown on the Drawings.

305.04.2 Basis of Payment

The amount of completed and accepted work, measured as provided for above, will be paid for at the unit rates for the various items in the Bills of Quantities , which rate shall be full compensation for equipment, tools, labor, supplying materials, transporting and placing, and for other items necessary for the proper completion of the work.

305.04.3 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
305.1	Cement Stabilized Base Course (Thickness)	sq.m
305.2	Curing Seal	sq.m

306 - RECYCLED AGGREGATE SUB-BASE COURSE

306.01 DESCRIPTION

The work shall consist of the construction of recycled aggregate subbase courses under flexible and rigid pavements resulting only from the crushing of Portland cement concrete structures and elements.

306.02 MATERIALS REQUIREMENTS FOR RECYCLED AGGREGATE

306.02.1 Aggregate Materials

The recycled aggregate subbase material shall consist of fine and coarse aggregate, the combination of materials shall conform to the requirements of ASTM D2940, unless otherwise specified under Clause 306 herein.

Coarse Aggregate: shall consist of durable crushed particles of Portland cement concrete and shall meet the following requirements:

1. Aggregates retained on the No. 4 (4.75 mm) sieve shall be capable of withstanding the effects of handling, spreading, and compacting without degradation production or deleterious fines.

2. Coarse aggregates shall comply with the requirements shown in Table 306.02.1

Fine Aggregate: Aggregates passing the No. 4 (4.75 mm) sieve shall consist of fines from the operation of crushing course aggregate.

1. Natural sand, or finer mineral matter, or both, may be added where available and suitable.

2. Fine aggregate shall comply with the requirements shown in Table 306.02.1

Property	Fine Particles	Coarse Particles
Los Angeles Abrasion Wear (ASTM C131)		40% max.
Soundness (5 cycles ASTM C88)	15% max.	15% max.
Crushed Aggregate (% Material Retained on 3/8 inch sieve (9.5 mm) by wt., having at least two (2) fractured faces)		50% max.
Maximum % passing No. 200 (75 μm)	50% of the passing No. 40 (0.475 mm)	
Plasticity Index (Material finer than No. 40 sieve) (425 μm)	4.0 max.	
Sand Equivalent Value	35 min.	

Table 306.02.1. Required Properties for Recycled Aggregate Subbase Material

Gradation: The combined recycled aggregate gradation shall comply with the gradation ranges and tolerances shown in Table 306.02.2

Sieve Size/Type	Percent Passing (Production Range A)	Percent Passing (Production Range B)	Production Tolerances (+/-%)
1-1/2 inch (38.1 mm)	100	100	-
1 inch (25.4 mm)	95 - 100	100	-
3/4 inch (19.1 mm)	-	90 - 100	8
1/2 inch (12.7 mm)	65 - 75	-	8
3/8 inch (9.5 mm)	-	65 - 80	8
No. 4 (4.75 mm)	34 - 46	48 - 55	8
No. 30 (600 µm)	12 - 18	18 - 25	5
No. 200 (600 µm)	5 - 12	6 - 15	3

Table 306.02.2. Recycled Aggregate Gradation Ranges and Tolerances

306.02.2 Sampling and Testing

A sample of material delivered to the project shall be taken for each 700 cu.m. placed or for each day's placement, whichever is greater, and shall be tested for the set of properties and gradation specified under Tables 306.02.1 and 306.02.2 above. The use of gradation of the production range A or B shall be determined in coordination with the Engineer on Site.

Noncompliant material shall be resampled and retested for compliance. Material not in compliance after the initial and follow-up testing shall be removed and replaced by the Contractor at no cost to the Contract.

306.03 CONSTRUCTION REQUIREMENTS FOR RECYCLED AGGREGATE SUBBASE COURSE

306.03.1 Finished Subgrade Levels

Prior to commencing the construction of the recycled subbase course, it is necessary to make sure that the subgrade conforms to the specifications and is compacted to the Maximum Dry Density as indicated in Section 2 (Earthworks) of these Specifications, and that the surface thereof conforms to the levels and slopes indicated in the Drawings. In all cases, the approval of the Engineer must be obtained before commencing spreading of recycled aggregate subbase course material.

306.03.2 Spreading and Compacting

Samples of the approved recycled aggregate material shall be taken in order to determine the Optimum Moisture Content.

Material shall then be spread on the road surface to thickness that would result in layers not more than 150 mm thick after compaction.

The natural moisture content of materials constituting the recycled aggregate subbase course shall be determined. If the natural moisture content is less than the optimum moisture content, the necessary amount of water must be added to obtain the optimum content, allowing for the quantity which may be lost by evaporation in the process of raking, leveling and compacting, depending on atmospheric temperature, quantity of material and the equipment and plant to be used in this operation. The layer shall be compacted when the moisture content

therein is within ±2% of the optimum moisture content in order to obtain Maximum Dry Density, and the moisture content is uniform in all parts of the section where the work is being carried out and in the various depths of the layer thickness.

Compaction shall start immediately thereafter, by means of pneumatic and steel rollers or vibratory rollers and in accordance with the instructions of the Engineer.

Compaction must start with rollers from extreme sides proceeding gradually toward the road axis. Rolling shall continue until the entire thickness of the recycled aggregate subbase course layer is thoroughly and uniformly compacted to 100% AASHTO T 180 (Method D) maximum density. Final rolling of the completed course shall be by means of an approved self-propelled roller. Rolling shall be accompanied by sufficient blading, to insure a smooth surface, free from ruts or ridges and having the proper shape. When additional water is required, it shall be applied in an approved manner.

306.03.3 Multi-Layers

During all the above-mentioned operations of spreading, compacting and leveling the recycled aggregate subbase course material, care must be taken so that layers already compacted under the layer being executed are not affected, or that the finished subgrade surface is also not affected. This aspect must be given special attention in places where equipment makes turns in going back and forth and any such damage resulting in mixing the various layers shall be carefully made good by the Contractor at his expense and to the satisfaction of the Engineer.

If more than one subbase course layer is required for reaching the required thickness indicated on the Drawings or described in the Specifications, each such course layer will be constructed as hereinbefore described.

Where the finished compacted thickness exceeds 150mm, placing shall be executed in composite layers each layer not exceeding 150mm in compacted thickness as directed by the Engineer.

306.03.4 Protection of Surface

The Contractor shall protect the recycled aggregate subbase course so that it shall be maintained sound during work progress, after its completion and prior to receiving the subsequent pavement layers. Any damage caused to the layer if exposed to traffic or natural conditions resulting in damage of its surface should be made good at the expense of the Contractor and to the satisfaction of the Engineer.

The recycled aggregate subbase course shall not be rolled when the underlying material is soft or yielding or when the rolling causes a wave-like motion in this course.

When the rolling develops irregularities, the irregular surface shall be loosened, then refilled with the same kind of material as used in constructing the course and again rolled according to Specifications. Along places inaccessible to rollers, the subbase course material shall be tamped thoroughly with mechanical tampers.

Work on the recycled aggregate subbase course shall not be permitted during rainy weather.

Hauling equipment may be routed over completed portion of the recycled aggregate subbase course provided no damage results and provided that such equipment is routed over the full width of the course to avoid rutting or uneven compaction.

The Engineer has the right to stop all hauling over completed or partially completed recycled aggregate subbase course when in his opinion such hauling is causing damage.

306.03.5 Testing and Acceptance of Recycled Aggregate Subbase Course

Prior to the application of any subsequent paving course, the recycled aggregate subbase course shall have been tested and accepted by the Engineer. The following shall be adhered to in accepting completed recycled aggregate subbase course:

A. Strength Specification for Compacted Recycled Aggregate Subbase Course

The recycled aggregate subbase course shall be compacted and tested for acceptance in accordance with the compaction requirements of Clause 306.03.2 of these Specifications.

In addition, the recycled aggregate subbase course shall be tested for the degree and uniformity of stiffness by measuring the in-situ deflections. The test method will be a measurement of dynamic deflection using the Dynaflect equipment.

The results of Dynaflect testing shall be considered a measure of conformance to specification requirements for aggregate sub-base and base courses.

Dynaflect testing shall be performed on permanent works and on Type IV – Long Term Detours.

The deflection limits for Dynaflect testing shall be as shown in Table 303.03.7 for conventional aggregate subbase course.

Dynaflect testing shall be performed longitudinally across the full width of the recycled aggregate subbase course. Testing will be at maximum intervals of 25 metres and representing a maximum width of 4 metres.

A minimum of 5 tests shall be made on every strip tested.

The Contractor shall be notified by the Engineer that the tested layer is accepted or rejected within 24 hours, excluding Fridays and Kuwait holidays, following the time the Dynaflect test was performed by the Contractor under the Engineer's direction, and the results were handed over to the Engineer.

Where Dynaflect test results fail to meet minimum deflection requirements, the Contractor shall at his expense rework, recompact or if necessary remove and replace the work as required to produce satisfactory test results.

In the event that Dynaflect testing of a layer is not possible, the work may be accepted at the discretion of the Engineer on the basis of satisfactory density results. In such cases, however, the subsequent layer shall only be accepted on the basis of Dynaflect tests.

B. Requirements for Compaction

Wherever the degree of compaction is found to be less than the 100% specified, the area of recycled aggregate subbase course involved shall be satisfactorily corrected so that the specified density is achieved. One field density test shall be done for every 500 500 m^3 of every layer or whenever materials changed, whichever is less.

C. Requirements for Gradation

Wherever the gradation is found to be outside the limits specified, the area of recycled aggregate subbase course involved shall be scarified, removed or otherwise reworked as directed by the Engineer to provide a material within specification limits.

D. Requirements for Thickness

Wherever the thickness of compacted recycled aggregate subbase course is found to vary from the plan thickness by more than 10% the area involved shall be satisfactorily corrected to provide the required thickness constructed to the specified grade level. Thickness shall be measured for every 2000 500 m^2 and for every layer.

E. Requirements for Evenness of Surface and Grade Levels

The final surfaces of the recycled aggregate subbase course shall be tested by means of a 4 meter long straight edge, and no rises or depressions in excess of 10 mm shall appear in the surface. Likewise, the finished surface shall be constructed to the specified grade levels with a tolerance of +5 mm or -10mm. The minus tolerance shall be compensated by the subsequent layer.

Where these requirements are not met, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the course by scarifying to a minimum depth of 75 mm or 4 times the maximum particle size, whichever is the greater, reshaping by adding or removing material as necessary and recompacting in accordance with the Specifications.

The elevations of the finished recycled aggregate subbase course shall be checked by the Contractor in the presence of the Engineer at intervals of 20m on straight lines and of 10 m on curves, and at intermediate points as directed.

306.04 MEASUREMENT AND PAYMENT OF THE RECYLED AGGREGATE SUBBASE COURSE

306.04.1 Measurement

Measurement of recycled aggregate subbase course shall be by meter square of the specified thickness laid and compacted in place for the type required in accordance with the Drawings, Specifications or as directed by the Engineer and shall be calculated from the top surface area, excluding tapered edges which shall be included in the rate.

No measurement shall be made for direct payment of overdepth construction, regardless of the Engineer's permission for it to remain in place.

306.04.2 Payment

Payment shall be made at the rate indicated in the Bills of Quantities which rate shall include for, but not by way of limitation, all labor, tools, plant, materials, transport, mixing, screening, spreading, rolling and compaction, shaping and leveling, testing, etc. and for everything necessary for the proper completion of the work in accordance with the Drawings, Specifications and instructions of the Engineer.

Where new road construction work adjoins or meets existing road construction, e.g. new shoulders and cross-roads, no separate payment will be made for cutting back the edges of the existing construction to receive new recycled aggregate subbase course layers, the cost being deemed to be included with the cost of the new recycled aggregate subbase course.

306.04.3 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
306.1	Recycled Aggregate Subbase Course (Type, Thickness)	sq.m

SECTION 4: ASPHALT WORKS

(For Cement Modified Aggregates see Clause 411)

400 - GENERAL

400.01 SCOPE

This Section contains the Requirements for Materials, Equipment, Design and Construction of Asphalt Works.

The General Requirements for Materials and Equipment given in Clauses 401, 402, and 403 shall be modified as indicated in the requirements for each specific type of asphalt work (Clauses 404 to 415 inclusive)

400.02 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

C 25 Standard Test Methods for Chemical Analysis of Limestone, Quick–Lime and Hydrated Lime
C 50 Standard Practice for Sampling, Sample Preparation, Packaging, and Marking of Lime and Limestone Products
C 51 Standard Terminology Relating to Lime and Limestone
C 150 Standard Specification for Portland Cement
C 207 Standard Specification for Hydrated Lime for Masonry Purposes
D 5 Standard Test Methods for Penetration of Bituminous Materials
D 36 Standard Test Methods for Softening Point of Bitumen (Ring-and-Ball Apparatus)
D 244 Standard Test Methods and Practices for Emulsified Asphalts
D 792 Standard Test Methods for Density and Specific Gravity (Relative Density of Plastic by Displacement)
D 1075 Standard Test Methods for Effect of Water on Compressive Strength of Compacted Bituminous Mixtures
D 1238 Standard Test Methods for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D 3387 Standard Test Methods for Compaction and Shear Properties of Bituminous Mixtures by Means of the U.S. Corps of Engineers Gyratory Testing Machine (GTM)
D 4402 Standard Test Methods for Viscosity Determination of Asphalt of Elevated Temperatures Using a Rotational Viscometer
D 4791 Standard Test Methods for Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
D 5821 Standard Test Methods for Determining the Percentage of Fractured Particles in Coarse Aggregate
D 6084 Standard Test Methods for Elastic Recovery of Bituminous Materials by Ductilometer
E 965 Standard Test Methods for Measuring Pavement Macrotexture Depth Using a Volumetric Technique

AASHTO

M 17 Mineral Filler for Bituminous Paving Mixtures
M 20 Penetration Graded Asphalt Cement
M 81 Cutback Asphalt (Rapid-Curing Type)
M 82 Cutback Asphalt (Medium-Curing Type)
M 85 Portland Cement
M 140 Emulsified Asphalt
M 156 Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
M 208 Cationic Emulsified Asphalt
M 226 Viscosity Graded Asphalt Cement
M 320 Performance-Graded Asphalt Binder
M 320-05 Performance Graded Asphalt Binder
R 28 Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
R 35-04 Superpave Volumetric Design for Hot Mix Asphalt (HMA)

T 2	Sampling of Aggregates
T 11	Materials Finer than 75μm (No. 200) Sieve in Mineral Aggregates by Washing
T 27	Sieve Analysis of Fine and Coarse Aggregates
T 30	Mechanical Analysis of Extracted Aggregate
T 40	Sampling Bituminous Materials
T 48	Flash and Fire Points by Cleveland Open Cup
T 53	Softening Point of Bitumen (Ring-and-Ball Apparatus)
T 59	Testing Emulsified Asphalts
T 90	Determining the Plastic Limit and Plasticity Index of Soils
T 96	Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
T 104	Soundness of Aggregate by Use of Sodium Sulphate or Magnesium Sulphate
T 113	Lightweight Pieces in Aggregate
T 164	Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
T 165	Effect of Water on Cohesion of Compacted Bituminous Mixtures
T 166	Bulk Specific Gravity of Compacted Hot Mix Asphalt Mixtures Using Saturated Surface Dry Specimens
T 168	Sampling Hot Mix Asphalt Paving Mixtures
T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
T 182	Coating and Stripping of Bitumen-Aggregate Mixtures
T 209	Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures
T 211	Determination of Cement Content in Cement Treated Aggregate by the Method of Titration
T 219	Testing Lime for Chemical Constituents and Particle Sizes
T 230	Determining Degree of Pavement Compaction of Bituminous Aggregate Mixtures
T 240	Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin-Film Oven Test)
T 245	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
T 283	Resistance of Compacted Hot Mix Asphalt to Moisture Induced Damage
T 301	Elastic Recovery Test of Bituminous Materials by Means of a Ductilometer
T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
T 312-08	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of Superpave Gyratory Compactor.
T 313	Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
T 314	Determining the Fracture Properties of Asphalt Binder in Direct Tension (DT)
T 315	Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

BS

BS EN 1097-3:1998	Tests for mechanical and physical properties of aggregates. Determination of loose bulk density and voids.
BS EN 932-6:1999	Tests for general properties of aggregates. Definitions of repeatability and reproducibility.
BS EN 933-1:1997	Tests for geometrical properties of aggregates. Determination of particle size distribution. Sieving method
BS EN 933-3:1997	Tests for geometrical properties of aggregates. Determination of particle shape. Flakiness index.
BS EN 933-7:1998	Tests for geometrical properties of aggregates. Determination of shell content. Percentage of shells in coarse aggregates.
BS EN 1097-2:1998	Tests for mechanical and physical properties of aggregates. Methods for the determination of resistance to fragmentation
BS EN 1744-1:1998	Tests for chemical properties of aggregates. Chemical analysis.
BS 812-110:1990	Testing aggregates. Methods for determination of aggregate crushing value (ACV).
BS 812-112:1990	Testing aggregates. Methods for determination of aggregate impact value (AIV).
BS 812-103.2:1989	Testing aggregates. Methods for determination of particle size distribution. Sedimentation test.

BS 812-105.2:1990	Testing aggregates. Methods for determination of particle shape. Elongation index of coarse aggregate.
BS 812-109:1990	Testing aggregates. Methods for determination of moisture content
BS 812-121:1989	Methods for determination of soundness.
BS 812-123:1999	Testing aggregates Methods for determination of alkali-silica reactivity. Concrete prism method Ties for Cavity Wall.
BSEN 1260:2002	Specifications for aggregates from natural sources for concrete

ASPHALT INSTITUTE

MS–02	Methods for Asphalt Mix Design
CP–06	Computer - Assisted Asphalt Mixture Analysis
AI	Superpave Mix Design Manual

MINISTRY OF PUBLIC WORKS

MPW	"Test for Soft and Friable Particles (Mesh)"
MPW	"Standard Test Procedure for Measuring and Stripping and Heat Stability on Bitumen Aggregate Mixture in the Presence of Water"
MPW	"Test Procedure for Detection of Hydrated Lime in Loose Asphalt Mixes or Cores"

FEDERAL SPECIFICATIONS

VV-D-1078B Damping Fluid, Silicone Base

KUWAIT STANDARDS SPECIFICATIONS

KSS 436-1992 Kuwait Standards Specifications

401 - CONTROL OF MATERIALS FOR ASPHALT

401.01 SOURCES OF MATERIALS

The materials used in the work shall meet all quality requirements of the Contract. All materials shall be tested and approved before use. The Contractor shall notify the Engineer of the sources of materials and the Engineer shall approve the sources prior to delivery of materials to the site. Where a source of material does not meet Specification requirements, the Contractor shall furnish material from other sources. Delivery of materials produced from commercial manufacturing processes shall be accompanied by the manufacturer's certification and test report showing the materials comply with the Specification requirements.

401.02 STORAGE AND HANDLING OF MATERIALS

Materials shall be so stored and handled as to assure the preservation of their quality and fitness for the work. Materials, even though approved before storage or handling, may again be inspected and tested prior to use in the work. Stored material shall be located so as to facilitate their prompt inspection. All storage sites shall be restored to their original condition at the Contractor's expense prior to acceptance of the Works.

Handling and stockpiling of aggregates shall at all times be such as to eliminate segregation or contamination of the various sizes. Stockpiles shall be kept flat and the formation of high cone-shaped piles shall not be permitted. When conveyor belts are used for stockpiling aggregates, the Engineer may require the use of baffle-chutes or perforated chimneys. When trucks are used to construct stockpiles, the stockpiles shall be constructed one layer at a time with trucks depositing their loads as close to the previous load as possible. The use of tractors or loaders to push material deposited at one location to another location in the stockpile shall not be allowed during the construction of the stockpile and their use shall be limited to leveling the deposited material only. Stockpiles of aggregate located at permanent asphalt plant sites shall be separated by bin walls and shall be constructed on asphaltic or concrete floors, Stockpile locations and procedures at temporary asphalt plant sites shall be as approved by the Engineer.

The Contractor shall provide an adequate storage facility for bitumen, at the site of the mixing plant. This

facility should be clean and stable and provided with cover and shelter from excessive temperatures. No open fires or smoking shall be allowed in or around the storage facility. The storage capacity should be sufficient to maintain a uniform operation while allowing for delayed shipments and time for testing. Different batches of bitumen should be separated, so as to allow for easy identification. If the bitumen is delivered to the site in metal drums, on arrival the drums shall be inspected for perforations, rusting, melting and/or other defects that would directly cause pollution or chemical changes to the bitumen. Depending on the severity of each case, the Engineer shall decide whether to retain or reject the affected drums. Any drum(s) showing any of these defects shall be rejected at the discretion of the Engineer. The stored bitumen products should be protected from temperatures which may exceed the range of -5^{o}C to +50^{o}C.

All transporting of bitumen shall be by conveyances that are free from contamination. Tank cars or tank trucks used for transporting bitumen shall be carefully inspected, drained, and cleaned if necessary, before loading, to prevent contamination of the bitumen from residues of previous loads. Bitumen may also be delivered and transported in metal drums. Tank trucks or trailers used to transport bitumen shall be equipped with an approved sampling device which shall be built into the tank or re-circulating or discharge line in such a manner that a sample can be drawn during circulation or discharge.

The Contractor shall take all necessary protection measures in the storage, handling and stockpiling of materials to prevent contamination of materials by dust. The measures that the Contractor proposes to take shall be subject to the approval of the Engineer.

Intermediate storage of hydrated lime and commercial mineral filler for equipment feeding the asphalt plant shall be silos of adequate sizes to ensure a minimum of one day's continuous operation.

401.03 INSPECTION, TESTING AND CONTROL OF MATERIALS

For verification of weights and measures, character of materials and determination of temperatures used in the preparation of the asphalt mixes, the Engineer will at all times have access to all portions of the mixing plant, aggregate plant, storage yards, crushers and other facilities used for producing and processing the materials of construction. The Engineer shall have authority to take samples and perform tests thereon of any material supplied to the site from any source whatsoever in order to establish their compliance with Specifications and to accept or reject as he deems necessary. Samples shall also be taken from completed work to determine compliance with the Specifications. Procedures for sampling of bituminous materials shall conform to AASHTO T 40. The frequency of all sampling and testing shall be in accordance with these Specifications and/or as directed by the Engineer. Testing for conformity of bitumen products shall be carried out to AASHTO and other specified standards.

Heating equipment shall be of an approved type. Any method of agitation or heating that introduces free steam or moisture into the bitumen will not be approved. During the process of its manufacture, conveyance, storage, or construction use, bitumen of whatever type shall not be heated to temperatures more than 10 degrees C above the maximum application temperature specified for the respective type of bitumen nor above 170 degrees C, whichever is the lower. Materials heated in excess of these temperatures will be rejected and shall not be used in the Works. Tanks for heating and storage of bitumen shall be capable of heating the material, under effective and positive control at all times, to the specified temperature. The system shall provide uniform heating for the entire contents of the tank. The circulation system shall be of adequate size to insure proper and continuous circulation of the bitumen during the entire operating period. Suitable means shall be provided, either by steam or oil jacketing, or other insulation, for maintaining the required temperature of bitumen, weigh buckets, spray bars, and other containers. Thermometers of approved type and adequate range (calibrated in 2 degrees C increments) for accurately measuring the temperature of the bitumen while heating, shall be located so as to be readily visible and shall be kept clean and in proper working order at all times. Where storage tanks are required, their capacity shall be sufficient for at least one day's production. Bitumen materials, wasted through careless handling or rendered unsuitable for use by overheating shall not be used in the Works.

401.04 SITE LABORATORY

Refer to Section 10 of this specification.

401.05 UNACCEPTABLE MATERIALS

Materials that do not conform to the requirements of the Specifications shall be rejected and removed immediately from the Site of the Works unless otherwise instructed by the Engineer. No rejected material, the

defects of which have been corrected, shall be used until approval has been given by the Engineer.

402 - MATERIAL REQUIREMENTS FOR ASPHALT WORKS

402.01 FINE AGGREGATE FOR ASPHALT WORKS

Fine aggregate is that portion of the mineral aggregate passing the No. 8 Sieve. Fine aggregate shall consist of natural sand and/or crushed sand and shall be of such gradation that when combined with other aggregates in proper proportions, the resultant mixture will meet the required gradation. The source of natural fine aggregate is considered to be the pit from which it is excavated and the source of crushed fine aggregate is considered as the crusher site at which it is produced. Crushed sand shall be produced by crushing clean coarse aggregate and shall not be thin, flaky or elongated. Sampling of fine aggregate shall be in accordance with AASHTO T-2. Sieve analysis shall be in accordance with AASHTO T27 and AASHTO T11.

Fine aggregate shall be clean and free from organic matter, clay, cemented particles and other extraneous or detrimental materials. Individual stockpiles of natural sand when tested in accordance with AASHTO T176 shall have a sand equivalent of not less than 45. Individual stockpiles of crushed sand shall have a sand equivalent of not less than 30. Individual stockpiles of aggregate containing more than 10% by weight of fine aggregate shall be tested for sand equivalent, crushed sand shall be from the same source of crushed aggregates used in the job mix.

Fine aggregate shall be subject to Sodium Sulphate Soundness loss tests (AASHTO T-104). The maximum allowable sodium sulphate soundness loss shall be 15%.

402.02 COARSE AGGREGATE FOR ASPHALT WORKS

Coarse aggregate is that portion of the mineral aggregate retained on the No. 8 Sieve. Coarse aggregate shall consist of crushed natural stones and gravel. Crushed particles shall be cubic and angular in shape and shall not be thin, flaky or elongated. The gradation shall be such that when combined with other aggregate fractions in proper proportions, the resultant mixture will meet the required gradation.

The source of crushed aggregate is considered to be the crushing site from which it is produced. Sampling of coarse aggregate shall be in accordance with AASHTO T2. Sieve analysis shall be in accordance with AASHTO T27 and AASHTO T-11.

Coarse aggregate shall be hard, durable, sound, clean and free from organic matter, clay, cemented particles and other extraneous or detrimental material. The degree of crushing shall be such that at least 90% of weight of the material retained on the No. 8 Sieve has 2 or more fractured faces when tested in accordance with ASTM D 5821. If required in the special specification, the coarse fraction of the aggregates for use in bituminous wearing course shall consist of 100% crushed stone from a hard, high quality Gabbro and/or non-vesicular Basalt.

The percentage by weight of soft and friable particles (mesh) for combined aggregates shall not exceed 2% for Type I and II Courses and 1% for Type III Courses.

Coarse aggregate shall be subject to sodium sulphate and magnesium sulphate soundness loss tests (AASHTO T104). The maximum allowable sodium sulphate soundness loss shall be 10%, and the maximum allowable magnesium sulphate soundness loss shall be 12%.

The abrasion loss (AASHTO T96) for coarse aggregate used in asphalt mixtures shall not exceed 25% for wearing course and 35% for asphaltic Base and Binder Courses when the surface of these courses is not to be subjected to traffic.

The Aggregate Crushing Value (ACV) and Aggregate Impact Value (AIV), as determined by BS812: Parts 110 and 112, shall be a maximum of 20% for the wearing course aggregates and a maximum of 25% for the binder and base course aggregates.

The aggregate shall not contain more than 8 percent by weight of flat or elongated pieces, when tested in accordance with ASTM D 4791.

All coarse aggregates from material sources in Kuwait and from aggregates sources (other than gabbro) that are to be used in the production of asphalt concrete shall be cement coated as per Clause 411 of these

Specifications.

Only gabbro aggregates may be used without cement coating provided that all mix design requirement of Clause 411.02.2 of these Specifications are met.

Approval has been granted for the use of imported Gabbro aggregate (basic rock) in all asphalt pavement layers provided the mix designs are found to perform satisfactory in terms of the cement coated mixes specifications.

The material from hot bins passing No. 4 sieve (0.425mm) when tested in accordance with AASHTO T90 shall be non plastic. In addition, the material from cold bins should not have a PI larger than 4%.

The flakiness and elongation indices shall meet the following maximum limits, when tested in accordance with BS 812:

	Bituminous Wearing Course	Bituminous Binder & Base Course
- Flakiness Index	25	30
- Elongation Index	25	30

Aggregates shall not contain gypsum more than 1% and the coarse fraction of the aggregate shall not contain more than 5% Chert when tested in accordance with AASHTO T113.

Aggregates shall be washed if directed, to remove any clay lumps, organic matter, adherent dust or clay films or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.

Polish Stone Value (PSV) of coarse aggregates used in the wearing course mix when tested according to BS 812 shall be at least 60%.

When tested for resistance to stripping in accordance with the AASHTO T-182 at least 95% coated particles should be achieved. If resistance to stripping is not achieved then anti-stripping agent should be used.

402.03 COMMERCIAL MINERAL FILLER

Commercial mineral filler shall consist of finely ground particles of limestone, cement or hydrated lime in accordance with AASHTO M17. It shall be thoroughly dry and free from lumps and shall meet the following gradation requirements (Table 402.03.1):

U.S. Standard Sieve Size	Minimum Percent Passing by Dry Weight
0.600mm (No. 30)	100
0.300mm (No. 50)	95-100
0.075mm (No. 200)	70-100

Table 402.03.1 - Gradation of Commercial Mineral Filler

Where hydrated lime is used as mineral filler, the hydrated lime shall conform to Clause 402.07 of these Specifications. When cement is used as mineral filler, it shall meet the requirements of Type I, II or V in accordance with AASHTO M85 (ASTM C150). Cement shall be used solely as mineral filler in the wearing course.

402.04 ASPHALT CEMENT (BITUMEN)

The asphalt cement (Bitumen) specified for use in the asphalt mixes shall be 60-70 Penetration Grade in accordance with AASHTO M20 and as shown in the Table 402.04.1.

Test	Min.	Max
Penetration @ 25°C (77°F) 100 g. 5 sec.	60	70
Flash Point, Cleveland Open Cup °C (° F)	232 (450)	
Solubility in Trichloroethylene, per cent	99	
Thin Film Oven Test, 3.2mm (1/8 inch) 163°C (325°F) 5-hour		
Loss on Heating, %		80
Penetration of Residue, % of Original	54	
Ductility @ 25°C, cm	100	
Ductility of Residue @ 25°C (77°F) 5 cm per minute cm	50	
Specific Gravity at 25 °C	1.01	1.06
Ash content (% wt)		1.0

Table 402.04.1 - 60-70 Penetration Grade Asphalt Cement

Asphalt cement not meeting the requirements of 60 -70 Penetration Grade may be accepted if it complies with Viscosity Grade AC-40 in accordance with AASHTO M226 as shown in Table 402.04.2:

Test	Min.	Max.
Viscosity, 60°C (140°F) poises	3200	4800
Viscosity. 135°C (275°C) Cs	300	-
Penetration 25°C (77°F), 100 g. 5 sec.	20	-
Flash Point, Cleveland Open Cup °C (°F)	232 (450)	-
Solubility in Trichloroethylene, percent	99	-
Test on Residue, Thin Film Oven Test:		
Viscosity, 60°C (140°F)	-	16000
Ductility, 25°C (77°F) 5 cm. per min. cm.	10	

Table 402.04.2 - AC-40 Viscosity Grade Asphalt Cement

The asphalt cement shall be prepared by the refining of petroleum. It shall be uniform in character and shall not foam when heated to 175°C (347°F). Blending of asphalt cement materials from different refineries will be permitted only with the written approval of the Engineer.

Asphalt Cement 60-70 Penetration Grade shall be applied at a temperature range of 145-165 °C.

402.05 BITUMEN MODIFIER AND MODIFIED BITUMINOUS MATERIAL

An approved modifier shall be incorporated in all penetration graded bituminous material whenever specified immediately prior to the time of use, unless otherwise shown on the Drawings.

The type and penetration grade of the original bituminous materials shall be submitted by the polymer supplier/Contractor to the Engineer's approval.

The Contractor shall provide his list of experience to prove that he is currently supplying and executing polymer modified bitumen on similar projects with successful results and performance. The Contractor shall submit data, which indicates that the product has a proven record of performance regarding compatibility with asphaltic concrete

The modified bitumen shall demonstrate significantly reduced temperature susceptibility and/or improved adhesive qualities. The workability of the modified bitumen shall be unchanged from that of unmodified bitumen.

Unless specified otherwise under these specifications, the mixing and preparation of modified bitumen shall be carried out in accordance with the manufacturer's instructions, and with the approval of the Engineer.

The Contractor shall submit a Method Statement for the preparation of Polymer Modified Bitumen (PMB) blending including the type of polymer intended for use to the Engineer's approval. The Contractor shall propose

the type of polymer he will be using for the Engineer's approval and shall demonstrate through testing that the modified asphalt meets all the specification requirements. The blending of the asphalt cement and the modifier will be accomplished by the supplier of the Modifier in a mobile mixing plant adjacent to the Contractor's asphalt plant on Site. The Contractor shall submit for the Engineer's approval a comprehensive Quality Assurance/Quality Control (QA/QC) program to ensure that the pre-blended polymer modified asphalt is delivered, stored in suitable conditions, incorporated in the bitumen mix and laid in strict accordance with the manufacturer's instructions. The minimum requirements for this program shall include but shall not be limited to the following:

i. Compatibility with original bitumen: The modified bitumen shall be tested for compatibility with the polymer modifier to ASTM D5892 for both Softening Point and Dynamic Shear (DSR). The difference in °C between the softening points of the respective top and bottom portions of the tube sample shall not exceed 4°C. The separation ratio based on G* shall have an average G* value [(Top + bottom) / 2] within 0.8 to 1.2 of the initial G* value. Alternative compatibility test according to ASTM D5841 can be carried out in lieu of ASTM D5892, only in case the Contractor/Supplier can prove that the ASTM D5892 cannot be adopted for the type of polymer proposed.

ii. Mixing and compaction temperatures: The mixing and compaction temperatures shall be established in the laboratory by determining the Brookfield viscosity of the approved Polymer Modified Bitumen at three different temperatures 135° C, 165° C and 195° C. The established mixing and compaction temperatures shall then be evaluated and finalized based upon successful site trials.

iii. Proportion of modifier in the mix: Depending upon the results of the tests specified in Table 402.05.1 below, the proportion of modifier to be used and the quality control procedures during mixing shall be determined in accordance with the manufacturer's recommendations to provide the optimum characteristics of the mix as specified below.

The minimum requirements and tests to be performed on the modified bitumen shall be as follows:

i. If the Styrene-Butadiene-Styrene (SBS) polymer is used, it shall have the following properties:

- Butadiene-Styrene Ratio = 70/30.
- Block Styrene = 30%.
- Hardness Shore A = 80.
- Density ASTM D792 = 0.93 – 0.95 g/cm3.

ii. If Polyethylene polymer is used, it shall be polyolefinic, primarily low density polyethylene and shall meet the following requirements:

Test Property	Criterion	Specification
Density	0.910 min. 0.940 max.	ASTM D 792
Melt Index	1.0 – 15.0	ASTM D 1238
Melting Point	110° – 135° C	

iii. If Latex Rubber is used, it shall have the following properties:

–	Non-volatile content:	68 ± 1
–	pH:	11.5 ± 1.0
–	Viscosity@25C, mPa.s:	1600 max.

iv. The ratio of modifier to bitumen in the completed mix is to be between 4 and 8 parts of modifier for 100 parts of bitumen, according to the manufacturer's recommendations, to be confirmed by the specified test results in Table 402.05.1 that will prove the optimized properties of the modified binder at the proposed proportion of modifier.

v. The modified bitumen properties shall comply with the requirements of the latest revision of AASHTO M320 specifications and to the requirements of Table 402.05.1.

vi.

	Property	Test Standard	Requirements	Frequency of Testing
1.	Penetration, 25° C, 100g, 5s, dmm	ASTM D5	to be agreed with the Manufacturer	at each batch
2.	Softening Point, °C	ASTM D36, AASHTO T53	Min. 65	at each batch
3.	Viscosity (Brookfield) at 135° C, max °C	ASTM D4402	3000 CP	at each batch
4.	Flash Point Temp, min °C	AASHTO T48	230 °C	every 500 tons
5.	Dynamic Shear before RTFOT, G*/sin ∂, Min. 1.00 kPa, test temperature @ 10 rad/s, °C, (Where G* = Dynamic Shear Modulus and ∂ = phase angle)	AASHTO TP5	76 °C	every 500 tons
6.	Rolling Thin Film Oven (RTFO) Mass Loss, max, %	AASHTO T240	1%	at each batch
7.	Elastic Recovery[1], 25° C, 10cm elongation, % after RTFOT	ASTM D6084, AASHTO T301	75	at each batch
8.	Dynamic Shear after Rolling Thin Film Oven Test (RTFOT), G*/sin ∂, Min. 2.2 kPa, test temperature @ 10 rad/s, °C	AASHTO TP5	76 °C	every 500 tons
9.	Compatibility Test	ASTM D5892	See requirements specified under this same Clause above	every 500 tons

Table 402.05.1 – Modified Bitumen (Performance Grade) Properties

The elastic recovery specified under Item 7 of Table 402.05.1 above corresponds to modified bitumen with either an elastomer or a blend of elastomer and plastomer polymers. Should the Contractor opt to use plastomer type polymer only, for the asphalt modification, then the Elastic Recovery requirement can be substituted by a set of tests that shall be carried out at the start of the project, with each set containing three samples, and the results shall conform to the following Table:

Property	Test Standard	Requirements
Pressure Aging Vessel Residue		
Pressure Aging Vessel (PAV) Aging Temperature, °C.	AASHTO R28	110 °C
Dynamic Shear, G*sin∂, Maximum 5000 kPa, Test temperature @ 10 rad/s, °C.	AASHTO T315	37 °C
Physical Hardening	Report	
Creep Stiffness, S, Maximum 300 MPa m-value, minimum 0.300 Test temperature @ 60 s, °C.	AASHTO T313	0 °C
Direct tension, Failure strain, minimum 1.0% Test temperature @ 1.0 mm/min, °C.	AASHTO T314	0 °C

Table 402.05.2 – Additional tests required for Plastomer Type Polymer

vii. The Contractor shall obtain from the manufacturer and provide to the Engineer periodical certificates stating that the modifier is being incorporated in the bitumen mix in accordance with the approved QA/QC program.

The percentage of the polymer to be mixed with the conventional bitumen to modify the latter shall be based on tests to satisfy the job mix formula.

The modifier shall be pre-blended into the conventional bitumen before mixing with the aggregate in the hot mix plant.

Blending Equipment: The production of the modified bitumen shall require a specialized high shear blending machinery to ensure complete and controlled dispersion and chemical reaction of the modifiers with the conventional bitumen.

402.06 LIQUID AND EMULSIFIED ASPHALTS

Liquid asphalt for use in asphalt works shall be MC-70 medium curing cutback asphalt (for prime coats) in accordance with AASHTO M82 and as modified by Tables 402.06.1 below:

Description	MC-70	
	MIN	MAX
Kinematic Viscosity @ 60°C centistokes	70	140
Flash Point (Tag Open Cup) °C (°F)	38 (100)	-
Distillation Test: Distillate (% by volume of total) distillation to 360°C (680°F)		
- To 225°C (437°F)	0	20
- To 260°C (500°F)	20	60
- To 315°C (600°F)	65	90
Residue from distillation to 360°C (680°F), % by volume % of sample by difference	55	
Tests on residue from distillation:		
Absolute viscosity at 60°C poises	300	1200
Ductility, 25°C (77°F), cm	100	
Solubility in Trichloroethylene, %	99	
Water, percent		0.2

Table 402.06.1 – Medium Curing Liquid Asphalt

MC-70 cutback bitumen spraying temperature shall be in the range of 45-80°C

Emulsified asphalt for use in asphalt works (mainly in tack coats) shall be CSS 1h cationic emulsified asphalt in accordance with AASHTO M208 or SS lh anionic emulsified asphalt in accordance with AASHTO M140 and Kuwaiti Standards Specifications KSS 436-1992 unless otherwise noted in these Specifications.

The manufacturer shall furnish samples of the base bitumen used in the emulsion.

When samples of undiluted emulsion are not readily available for test purposes, tests may be made on the diluted emulsion and the respective specifications modified to reflect the changes in properties resulting from dilution of the bitumen.

All emulsified bitumens shall adhere firmly to the surface of the mineral aggregate or the highway surface as appropriate. Failure of the emulsified bitumen to perform satisfactorily on the job shall be deemed cause for its rejection regardless of satisfactory laboratory test results.

402.06.1 Anionic Emulsified Bitumen

Anionic emulsified bitumen shall, prior to dilution, conform to the requirements of AASHTO M 140, for Types SS-1 and SS-1h and as listed in Table 402.06.2.

Sampling and testing shall be in accordance with AASHTO T 59.

	Slow-Setting			
	SS-1		SS-1h	
	Min	Max	Min	Max
Tests on emulsions: Viscosity, Saybolt Furol at 25 °C, s	20	100	20	100
Viscosity, Saybolt Furol at 50°C , s	-	-	-	-
Storage stability test, 24-h, %	-	1	-	1
Cement mixing test, %	-	2	-	2
Sieve test, %	-	0.1	-	0.1
Residue by distillation, %	57	-	57	-
Tests on residue from distillation test: Penetration, 25 °C,100 g, 5 s	100	200	40	90
Ductility, 25°C, 5 cm/min, cm	40	-	40	-
Solubility in trichloroethylene %	97.5	-	97.5	-

Table 402.06.2 – Properties of Anionic Emulsified Bitumen

Emulsified bitumen spraying temperature range shall be so that appropriate viscosity for each application is achieved, if however the viscosity curves are not available these values, generally considered as guidance, shall be 25-65 degrees C. The temperature range for pugmill mixing for medium and slow setting types shall be 15-65 degrees C.

402.06.2 Cationic Emulsified Bitumen

Cationic emulsified bitumens shall, prior to dilution, conform to the requirements of AASHTO M 208, for Types CSS-1 and as listed in Table 402.06.3.

	Slow Setting	
	CSS-1	
	Min	Max
Tests on emulsions: Viscosity, Saybolt Furol at 25°C, s	20	100
Storage stability test, 24-h, %	1	-
Particle charge test	Positive	
Sieve test, %	-	0.10
Cement mixing test, %	-	2.0
Distillation: Residue, %	57	-
Tests on residue from distillation test: Penetration, 25°C, 100 g, 5 s	100	250
Ductility, 25°C, 5 cm/min, cm	40	-
Solubility in trichloroethylene %	97.5	-

Table 402.06.3 – Properties of Cationic Emulsified Bitumen

Sampling and testing shall be in accordance with AASHTO T 59.

Emulsified bitumen spraying temperature range shall be so that appropriate viscosity for each application is achieved, if however the viscosity curve is not available these values, generally considered as guidance shall be 25-65 degrees C. The temperature range for pugmill mixing for medium and slow setting types shall be 15-65 degrees C.

402.07 HYDRATED LIME

Hydrated lime shall conform to the definitions given in ASTM C51 and shall meet the requirements of ASTM C 207 Type N. Sampling, packaging and marking of hydrated lime shall be in accordance with ASTM C50. Storage and use of the hydrated lime shall at all times be such as to protect the material from the weather.

Hydrated lime shall conform to the gradation shown in Table 402.07.1 when tested in accordance with AASHTO T219.

U.S. Standard Sieve Size	% Passing by dry mass
No. 30 (0.600 mm) No. 200 (0.075 mm)	96-100 70-100

Table 402.07.1 – Gradation of Hydrated Lime

403 - MAJOR EQUIPMENT USED FOR ASPHALT WORKS

403.01 GENERAL

The machinery and tools utilized in constructing the various items involved in Asphalt Works shall be in good working condition and the Contractor shall maintain and preserve them for the whole duration of the job. The Engineer shall approve the machinery and tools prior to the commencement of work, and the Contractor shall supply adequate quantities of such machinery in order to execute the work with due speed and precision. Equipment approved for use shall not be removed from the site without the approval of the Engineer.

The Contractor shall furnish the Engineer with the manufacturer's catalogues, specifications and other published data for the equipment and machinery he proposes to use.

403.02 ASPHALT MIXING PLANT

403.02.1 General

All plants used by the Contractor for the preparation of asphalt hot mixes shall conform to the following requirements: 403.02.2 “Requirements for All Plants”. Batch mixing plants shall conform to the requirements under 403.02.3 “Special Requirements for Batching Plants” and continuous mixing plants shall conform to the requirements under 403.02.4 “Special Requirements for Drier-Drum Mixing Plants”. Other types of asphalt mix production plants producing equivalent results may be furnished subject to the approval of the Engineer.

403.02.2 Requirements for All Plants

A. <u>Automatic Operation</u>

The plant shall be designed, coordinated and operated so as to continually produce asphalt mix within the job mix tolerances specified. The plant shall be equipped and operated so that the proportioning of the hot aggregate, commercial filler and bitumen, together with the dry and wet mixing cycles are all controlled automatically. Positive interlock shall be provided so that proportioning, mixing and discharge are accomplished by one operation without manual control of the separate phases.

B. <u>Cold Feed System</u>

The plant shall include a sufficient number of cold storage bins so that there is at least one bin for each different stockpile of material being used. Intermixing of material from different stockpiles in one bin or on the ground

prior to putting into the bin is prohibited. The cold bins and loading equipment used shall be compatible to prevent overflow between bins. Baffle plates shall also be used between bins to prevent overflow of one bin into another. Each cold bin shall include an accurate means for continuously feeding the required amount of mineral aggregate so that uniform production shall be approved by the Engineer and shall be checked and calibrated as often as he may deem necessary to ensure their continued accuracy. Change of settings shall be made only with the approval of the Engineer.

C. Hydrated Lime Additive System

If hydrated lime is used, an approved hydrated lime additive system shall be provided. This system shall uniformly feed the required quantities of hydrated lime and water to the total aggregate and thoroughly mix these materials prior to their entering the asphalt plant drier. The hydrated lime additive system shall be interlocked with the aggregate cold feed system in order to provide continual treatment of the aggregate. Adequate precautions shall be taken to protect the hydrated lime from loss or damage due to the weather, i.e. enclosed storage sheds with concrete flooring, storage silos, etc. The capacity of all components of the hydrated lime additive system shall be such as to ensure the continuous application of hydrated lime as specified.

Hydrated lime may be added dry or in slurry form. When added dry, the hydrated lime storage silo and the feeder shall have satisfactory means of preventing arching or intermittent flow. A sufficient number of vibrators, augers and the like may be required to ensure the uniform and continuous flow of lime. Sufficient water spray bars shall be provided to supply 0.5% to 4.0% water by weight of aggregate. Both the lime and water additive devices shall have well defined controls to enable easy checking, setting and calibration.

When hydrated lime is added as a slurry, a minimum of two slurry chambers will be provided. One chamber will be used for proportioning the hydrated lime and water into slurry consistency as directed by the Engineer. The second slurry chamber shall contain the mixed slurry and shall be provided with an accurate metering device with well defined settings to enable easy checking, setting and calibration. Both chambers shall be equipped with continuous mixing paddles or re-circulating pumps in order to prevent the slurry mixture from separating.

The hydrated lime system shall also include a mixing device of the drum, pugmill, auger type or other acceptable type. This device shall thoroughly mix the hydrated lime, water and total aggregate so that the resultant mixture is uniform in appearance and moisture content. The mixture may then be transferred directly to the asphalt plant drier or stockpiled for later use. Mixed material remaining in stockpile for more than 30 days may require additional treatment.

D. Drier

A drier of satisfactory design shall be provided. The drier shall be capable of uniformly drying and heating the aggregate to the moisture and temperature required without leaving any visible unburned oil or carbon residue on the aggregate when discharged from the drier.

E. Dust Collector

The plant shall be provided with a dust collector designed to waste or to return in a constant and uniform flow to the hot elevator, all or part of the material collected. Prior to permitting the return of such collected dust, the Engineer will examine its characteristics in relation to the mix requirements and will designate the quantity to be returned.

The plant shall have a screen cover and such additional housing as may be necessary to ensure the proper control of dust.

F. Screens

Plant screens shall be capable of screening all aggregates to the specified sizes and proportions. They shall have capacities equal to or greater than the maximum rated capacity of the plant. The screens shall be placed directly above the storage bins for the heated aggregate and shall receive the material coming from the drier. They shall have an operating efficiency such that the aggregate deposited in any bins shall not contain more than 10% of oversize or undersize material. This screen tolerance shall not invalidate the job mix tolerances specified.

G. Hot Bins

The plant shall include at least three storage bins for hot aggregate of sufficient size to supply the pugmill when it is operating at full capacity. They shall be arranged to ensure separate and adequate storage of appropriate fractions of the aggregate. Each compartment shall be provided with an overflow pipe that shall be of such size and at such location as to prevent any backing up of material into other bins or against the screens. Bins shall be so constructed that samples can be readily obtained therefrom. An additional dry storage bin shall be provided for commercial mineral filler and provision shall be made for proportioning this filler into the mix.

H. Equipment for Preparation of Bituminous Material

Tanks for storage of bituminous material shall be equipped for heating the material using positive and automatic control at all times, to a temperature within the specified range. The heating shall be accomplished by steam coils, hot oil, electricity or other approved means such that no flame shall come in contact with the heating tank.

The circulating system for the bituminous material shall be of adequate size to ensure proper and continuous circulation during the entire operating period. Suitable means shall be provided either by steam or hot oil jackets or other insulation for maintaining the specified temperature of the bituminous material in the pipeline, meters, weigh buckets, spray bars, and other containers and flow lines. The storage tank capacity shall be sufficient for at least one day's operation. Circulation return lines to the asphalt storage tanks should be submerged to the same elevation in the storage tanks as the feeder line. (Two or three vertical slots may be cut in the return line above the high level mark to break vacuum when reversing the pump).

The Contractor shall provide a sampling outlet in the bituminous material feedline connecting the plant storage tanks to the bituminous material weighing or metering box. The outlet shall consist of a valve installed in such a manner that samples may be withdrawn from the line slowly at any time during plant operation. The location of the sampling outlet shall be readily accessible and free from obstruction. A drainage receptacle shall be provided for flushing the outlet prior to sampling.

I. Thermometric Equipment

An armored thermometer reading from 38^{o}C to 204^{o}C shall be fixed in the bituminous feed line at a suitable location near the discharge valve. Similar devices shall be fixed in the heating and storage tanks.

The plant shall be further equipped with either an approved digital or dial-scale, mercury-actuated thermometer, an electric pyrometer, or other approved thermometric instruments placed at the discharge chute of the drier and in the hot fines bin so as to register automatically or indicate the temperature of the heated aggregates. For better regulation of the temperature of the aggregates, replacement of any thermometer by an approved temperature-recording apparatus may be required by the Engineer and he may further require that daily temperature charts be submitted to him by the Contractor.

J. Control of Mixing Time

The plant shall be equipped with positive means to govern the time of mixing and to maintain it constant unless changed at the direction of the Engineer.

K. Pugmill

The pugmill shall include equipment to deliver the bituminous materials in a thin uniform sheet or in multiple sprays over the full length of the mixer.

L. Temporary Storage of Mix

Plants may be equipped with skips or elevators for delivering hot mix to hoppers or silos before discharging to hauling units. The skips or elevators shall not be sprayed with diesel or other solvents; where necessary they may be sprayed with a minimum amount of lime water, soap or detergent solution. Hoppers or silos shall be of such design that no segregation or loss in temperature of the mix occurs.

M. Safety Requirements

Adequate and safe stairways to the mixer platform and guarded ladders to other plant units shall be placed at all points required for accessibility to all plant operations. Accessibility to the top of truck bodies shall be provided by means of a platform or other suitable device to enable the Engineer to obtain mixture temperature data. To

facilitate handling scale calibration equipment, sampling equipment, etc. a hoist or pulley system shall be provided to raise or lower the equipment from the ground to platform or vice versa. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed passage shall be maintained at all times in and around the truck loading space. This space shall be kept free from drippings from the mixing platform.

403.02.3 Special Requirements for Batching Plant

A. Weigh-Box Hopper

The plant shall include means for accurately weighing each size of aggregate in a weight-box or hopper, suspended on scales, ample in size to hold a full batch without hand raking or running over. The weight-box or hopper shall be supported on fulcrums and knife-edges so constructed that they will not be easily thrown out of alignment or adjustment. All edges, ends and sides of weighing hoppers shall be free from contact with any supporting rods and columns or other equipment that will in any way affect the proper functioning of the hopper. There shall also be sufficient clearance between hoppers and supporting devices to prevent accumulations of foreign materials. The discharge gate of the weigh box shall be so hung that the aggregate will not be segregated when dumped into the mixer and shall close tightly when the hopper is empty so that no material is allowed to leak into the batch in the mixer during the process of weighing the next batch.

B. Scales and Meters

Scales or meters used for proportioning aggregate, commercial filler and bitumen shall be accurate to 0.5 % of the indicated quantity. Scales and meters shall be substantially constructed and those that quickly get out of adjustment shall be replaced. Scales shall be constructed and located so as to prevent vibration in the dial pointer.

Scales for weighing aggregate and commercial filler may be either the beam or springless dial type and shall be of standard make and design. Graduation intervals shall be not more than 11 % of the nominal scale capacity. Dial scales shall be equipped with adjustable pointers for controlling automatically the weighing of each aggregate and filler. The pointer shall be set close to the dial face to prevent excessive parallax and all dial faces shall be so located that they will be in plain view of the operator at all times. Weighing sequence of hot aggregates shall progress from coarse to fine.

Bituminous material shall be automatically proportioned by either weighing or metering. The minimum graduation shall be not more than 1 litre or 1 kg. Bituminous scales and weigh buckets shall be such that the required amount of bitumen is provided in a single weighing and delivered to the pugmill without loss due to overflow, splashing or spillage. Bituminous weigh buckets shall be satisfactorily insulated to prevent loss of heat in the bitumen or accumulation of bitumen in the bucket. Bituminous metering devices shall be rotating positive displacement pumps and shall be capable of providing the designated quantity of material for each batch.

All scales and meters shall be approved by the Engineer and shall be checked and calibrated as often as he may deem necessary to ensure their continued accuracy. The Contractor shall provide and have at hand the necessary standard weights and other necessary equipment in order to perform testing and calibration of all scales and meters in a practical manner. An accurate platform scale with a capacity of 250 kg or more and an accuracy of 0.5 % of the load shall also be provided.

C. Pugmill Mixer

The batch mixer shall be an approved twin pugmill type, capable of producing a uniform mixture within the job-mix tolerances. It shall be so designed as to permit visual inspection of the mix. The mixer capacity shall be not less than 600 kg per batch and shall be so constructed as to prevent leakage of contents. The mixer shall be enclosed and shall have an accurate time lock to control the operation of a complete mixing cycle by locking the weigh box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the bitumen supply throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between opening of the weigh box gate and the start of application of bitumen.

The wet mixing period is the interval between the time the bituminous material is spread on the aggregate and the time the mixer gate is opened. The control of the time shall be flexible and capable of being set at intervals of not more than 5 seconds throughout cycles up to 3 minutes. A mechanical batch counter shall be so designed

as to register only completely mixed batches.

The mixer shall be equipped with a sufficient number of paddles or blades in a suitable arrangement to produce a proper and uniformly mixed batch. The clearance of blades from all fixed and moving parts shall not exceed 19mm (3/4 inch) except in the case of aggregates having a nominal maximum size of over 25mm (1 inch) in which case the clearance shall be so adjusted as to prevent undue breakage of the coarse aggregate during the mixing operation.

403.02.4 Special Requirements for Drier-Drum Mixing Plant

All of the provisions of Section 4 of these Specifications shall apply except that Clause 403.02.2 f, g, j and k shall not apply.

A. Proportioning for Drier-Drum Mixing

i. **Asphalt Cement**

Asphalt cement shall be discharged into the mixer through a meter conforming to the requirements of Clause 403.02.2h. Constant pressure shall be maintained at the meter and verified on a gauge installed between the meter and the mixer. The plant shall be capable of varying the rate of discharge of asphalt cement. During any day's run, the temperature of asphalt cement shall not vary more than 25ºC. The metering device shall be equipped to compensate for the asphalt liquid temperatures.

The meter and lines shall be heated and insulated to maintain the temperature of the line and measuring device near that temperature specified for the asphaltic material.

Asphaltic material entering the measuring device shall be maintained at +5ºC of the temperature at which the asphalt measuring device was calibrated and set.

The asphalt metering system shall have provisions to correct for variances in the specific gravity of the material being metered, and shall be equipped with an automatic readout indicating rate of the flow.

The storage for asphalt cement shall be equipped with a device for automatic plant cut-off when the level of asphalt cement is lowered sufficiently to expose the pump suction line.

ii. Cold-Feed Control

Cold-feed control shall be used with drier-drum mixing. The asphalt feed, each of the aggregate feeders, the dust feed, the combined aggregate feeder, and mineral filler feeder shall be equipped with devices by which the rate of feed can be determined while the plant is in full operation.

The combined aggregate shall be weighed using a belt scale equipped with an automatic readout indicating the weight of the material flow. The belt scale shall be of such accuracy that, when the plant is operating between 30% and 100% of belt capacity, the average difference between the indicated weight of material delivered and the actual weight delivered will not exceed one percent of the actual weight for three 2-minute runs. For any of the three individual 2-minute runs, the indicated weight of material delivered shall not vary from the actual weight delivered by more than 2% of the actual weight. The actual weight of material delivered shall be determined by a vehicle platform scale. The plant shall be equipped so that this accuracy check can be made prior to start of operation and at any time during production as directed by the Engineer.

The belt scale for the combined aggregate, the proportioning devices for mineral filler and the asphalt proportioning meter shall be interlocked so that the rates of feed of the aggregate and asphalt will be adjusted automatically to maintain the job mix formula. The plant shall not be operated unless this automatic system is operating and in good working condition.

Asphalt meters and aggregate belt scales used for metering the feed of aggregates and asphalt into the mixer shall provide accumulated totals for periodic production runs and be resettable to zero. This information is to be permanently recorded.

The bins containing the fine aggregate and mineral filler shall be equipped with vibrating units or air agitators which will prevent clogging or bridging of material in the bins while the plant is operating. Vibration of the bins shall be monitored by the Contractor to prevent clogging of the bins by over-vibrating. When the quantity of material in any one bin reaches the strike-off capacity of the feed gate, a device shall automatically close down

the plant.

The Contractor shall determine the moisture content of the aggregate as directed and shall adjust plant control equipment accordingly. A suitable automatic moisture sensing and compensating device may be used in lieu of periodic moisture sampling.

An aggregate sampling device which will provide a representative sample of combined aggregate while the plant is in full operation shall be installed ahead of the point where the aggregates enter the drier-drum mixer. Aggregate samples shall be split, if required under the supervision of the Engineer, to provide 25 to 35 kg of the combined aggregate.

B. Mixing

Aggregate mineral filler and asphaltic cement shall be fed directly to the drier-drum mixer at a uniform rate. At the time of laydown the asphalt mix shall not contain more than 1% moisture.

Bituminous mixes shall be produced in an approved type batch mixing plant of adequate size with a minimum capacity of not less than 80 ton/hr and a mixer capacity of not less than 750 kg. batch. The plant shall conform to the relevant requirements of AASHTO M 156.

Aggregates shall not be introduced at the reclaimed material feed.

The drier-drum mixer shall be provided with a device which indicates the temperature of the material leaving the mixer. The temperature indicating device shall be accurate within 5ºC and sensitive enough to reflect 5ºC change within one minute.

Mixing shall continue for sufficient time and at sufficiently high temperature so, upon discharge from the mixer, aggregates are uniformly distributed and all particles are thoroughly and uniformly coated with asphalt.

C. Asphalt Concrete Storage

The plant shall be equipped with one or more heated storage bins with a total storage capacity of at least 100 tonnes. There shall be a diverter gate or similar mechanism between the mixing drum and the storage system by which rejected material from the mixing drum can be diverted to a waste pile. The diverter shall be actuated by a servo mechanism controlled from the operator's console. The minimum quantity of asphalt concrete in storage during mixing shall be 20 tonnes except for the period immediately following a shutdown of the plant of 2 hours or more. A means shall be provided to indicate that storage in each silo is being maintained as required.

The storage silo shall be equipped to prevent segregation of the completed mix when discharged into the silo.

Overnight storage will not be permitted unless authorized in writing by the Engineer on a day-by-day basis. The mixture coming out of the storage silo must be of equal quality to that coming out of the drier-drum mixer.

Asphaltic concrete with lumps in the mixture shall not be used in the work. Discharge of mix with lumps from any silo shall result in rejection of the material for the work. The silo with lumps shall be purged of all asphalt lumps prior to being put back in use.

403.03 EQUIPMENT FOR HAULING

Vehicles used for the transport of aggregates or bituminous mix shall have tight, clean and smooth metal beds and shall be free from dust, screenings, petroleum oil, volatile or other mineral spirits which may affect the material being hauled. The vehicle metal bed shall, if required, be sprayed with a minimum amount of soapy water or lime solution to prevent bituminous mix from adhering to the bed. After spraying, the truck shall be raised and thoroughly drained; no excess solution shall be permitted. Use of diesel or other solvents to spray in the truck bed is prohibited. Provision shall be made for covering truck loads with canvas or other suitable material of such size as to protect bituminous mix from the weather.

When necessary, in order that a bituminous mixture be delivered on the road at the specified temperature, truck beds shall be insulated to obtain workable temperature of the mix and all covers shall be securely fastened. Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall, upon the direction of the Engineer, be removed from the work until such faults are corrected. End dump trucks shall be equipped with chains on the tail gates for control when dumping the mix into the paving machine.

Trucks shall be capable of dumping the asphaltic mixture ahead of the paver in a windrow compatible with the windrow elevator which is required to feed the paver.

The Contractor shall provide an adequate number of trucks of such size, speed and condition to ensure orderly and continuous operations of the work.

The dispatching of the hauling vehicles to the Site shall be so scheduled that all material delivered is placed at least 90 minutes before sunset to allow sufficient time for compaction, unless the use of artificial light is approved. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

The mix at delivery to the paver shall be not more than 10ºC below discharge temperature at the mixing plant. The minimum temperature for the commencement of breakdown rolling is 120ºC. Mix loads of temperature less than 120ºC shall not be accepted, and the load shall be disposed of and another load used. If there is consistent failure to meet the temperature requirement the Engineer shall order paving operations to stop until suitable measures are taken by the Contractor to ensure that temperature requirements are met.

The Contractor is to refer to Section 1 (General) of these Specifications on the use of certain roads by heavy vehicles during certain hours of the day/night.

403.04 SPREADING AND FINISHING EQUIPMENT

The asphaltic mixture shall be fed to the paver by means of a windrow elevator. Trucks shall not be allowed to dump directly into the paver. The asphaltic mixture shall be placed in a windrow ahead of the paver and be picked up by a windrow elevator which feeds the paver.

Bituminous courses shall be spread and finished using approved type, self-contained, power-propelled pavers of sufficient capacity to be capable of laying up to 80 ton/hr. Pavers shall be provided with electronically controlled vibratory screed or strike-off assembly with devices for heating the screed, and shall be capable of spreading and finishing the various courses of bituminous plant mix to the proper thickness and in lane and shoulder widths applicable to the typical cross sections shown on the Drawings, and in incremental widths down to 2.4 m minimum and up to 8 m maximum.

The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture uniformly in front of adjustable electronic controlled screeds. The pavers shall be so designed as to allow a minimum paving width of 2 meters, although paving in widths of less than 3 meters will require the prior approval of the Engineer. Pavers shall be equipped with such provisions and attachments to suit paving widths specified for road widening as well as to suit paving on sloped sections. They shall be equipped with fast and efficient steering devices and shall have reverse as well as forward travelling speeds. The operational speed of the pavers shall be adjustable from 3 to 6 meters per minute in accordance with the instructions of the Engineer.

The pavers shall employ mechanical devices as equalizing runners, straight edge runners, evener arms or other compensating devices to maintain trueness of grade and to confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint leveling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be designed and operated in such manner that it will place the material at the required compacted thickness.

The pavers shall be equipped with calibrated sensors to control the road profile in accordance with the design shown on the Drawings.

Electronic screeds shall include automatic feed controls to maintain a constant level of material along the full length of the screed, automatic grade control and automatic slope control. The grade controller shall be activated by a travelling, articulated averaging beam of not less than 9 meters in length. Short joint matching shoes shall not be used. The automatic slope control shall be equipped with a proportioning manual override to enable smooth transition of changing slope rates. Automatic screed controls shall be approved by the Engineer prior to use.

Screeds shall be provided with devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring. Pavers shall also be provided with the standard attachable screed extensions.

The terms "screed" includes any cutting, crowning or other physical action that is effective in producing a

finished surface of the evenness and texture specified, without tearing, shoving, or gouging the surfaces.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor.

403.05 ROLLERS

403.05.1 General

Rolling equipment shall consist of vibratory steel-wheeled rollers, steel-wheeled rollers and pneumatic-tyred rollers as required for proper compaction and finishing of the asphalt surface. Unless otherwise permitted, rollers shall be equipped with reversible or dual controls to allow operation both forward and backward with the operator always facing in the direction of movement.

403.05.2 Steel-wheeled Rollers

Steel-wheeled rollers shall be two-axle tandem rollers and three-axle tandem rollers. These rollers shall be self propelled and equipped with power units of not less than four cylinders and under working conditions shall develop contact pressures under the compression wheels of 45 to 65 kg/cm (250 to 360 lb/in) of width. Each two-axle roller shall have a minimum weight of 10,000 kg; each three-axle roller shall have a minimum weight of 13,000 kg. Vibrating steel-wheeled rollers shall have dual drums with a minimum weight of 7,000 kg. Vibrating frequency shall be between 2000 and 3000 cycles per minute with individual controls for each tandem drum. Rollers shall be in good working condition and shall be equipped with a reversing clutch. Rollers shall be equipped with adjustable scrapers to keep the wheel surface clean and with efficient means of keeping them wet to prevent mixes from sticking. These surfaces shall have no flat areas or projections which will mar the surface of the asphalt courses. The three-axle rollers shall be equipped with a centre axle which may be operated either fixed or floating. The three-axle tandem roller shall be so constructed that when locked in a position for all treads to be in one plane, the roller wheels are held with such rigidity that, if either front or centre wheel is unsupported the other two wheels will not vary from the place more than 6 mm (1/4 inch).

All steel-wheeled rollers shall be in good condition and the Contractor shall furnish to the Engineer the manufacturer's technical data for each roller and no roller shall be used except after approval of the Engineer.

403.05.3 Pneumatic-tyred Rollers

Pneumatic-tyred rollers shall be self-propelled. The rollers shall be equipped with pneumatic tyres of equal size and diameter which are capable of exerting average contact pressures varying from 2.8 to 8.4 kg/cm2 (40 to 120 psi) by adjusting the ballast and/or tyre inflation pressures. The wheels shall be so spaced that one pass will accomplish one complete coverage equal to the rolling width of the machine. There shall be a minimum of 6 mm (1/4 inch) overlap of the tracking wheels. The wheels shall oscillate but not wobble. The roller shall be so constructed that the contact pressures shall be uniform for all wheels and the pressure of all the tyres shall not vary more than 0.35 kg/cm2 (5 psi) one from another.

Pneumatic-tyred rollers shall be in good condition and with enough ballast space to provide uniform wheel loadings as may be required.

The Contractor shall furnish to the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of tyre inflation pressures and for the full range of tyre loadings for each type and size compactor tyre furnished and used in pneumatic-tyred rollers.

The total operating weight and tyre pressure may be varied by order of the Engineer to obtain contact pressures which will result in the required asphalt course density.

403.06 ASPHALT DISTRIBUTOR

The asphalt distributor truck shall be of the pressure type with insulated tanks. The use of gravity distributors will not be permitted. The distributor shall have pneumatic tyres of such width and number that the load produced on the road surface shall not exceed 100 kg/cm of tyre width.

Spray bars shall have a minimum length of 2.4 meters (8 feet) and shall be of the full circulating type. Spray bar

extensions shall also be of the full circulating type. The spray bar shall be adjustable to maintain a constant height above the surface to be treated. The spray bar nozzles shall be slotted and shall be of such design so as to provide a uniform unbroken spread of bituminous material on the surface. The valves shall be operated by levers so that one or all valves may be quickly opened or closed in one operation. The distributor shall be equipped with a hose and nozzle attachment to be used for spotting areas inaccessible to the distributor. The distributor and booster tanks shall be so maintained at all times as to prevent dripping of bituminous material from any part of the equipment.

The distributor shall be equipped with devices and charts to provide for accurate and rapid determination and control of the amount of bituminous material being applied and with a tachometer of the auxiliary wheel type reading speed in meters (feet) per minute. The spreading equipment shall be provided with a separate power unit for the pump or a variable displacement pump driven by a hydrostatic transmission so that a uniform application of bituminous material, in controlled amounts, may be made ranging from 0.15 to 5.0 kg/m2. The distributor shall have satisfactory heating equipment and thermometers in order to provide the full range of application temperatures for the bituminous material being used.

Prior to the commencement of the work and as required by the Engineer, the bituminous distributor shall be checked and calibrated such that the rate of transverse spread or longitudinal spread shall not vary more than ten percent from the required rate of application.

403.07 UNACCEPTABLE EQUIPMENT

The Engineer shall have the right to stop the use of any equipment or plant which he deems to be inferior to the quality required and to instruct the removal of such equipment and to have it replaced by suitable equipment.

The Contractor shall immediately comply with such instructions without being entitled to any indemnities or extensions as a result of such instructions. The Contractor shall not be allowed to use any equipment or plant before obtaining the approval of the Engineer, and the Contractor shall undertake to follow sound technical methods in operation and to engage skilled and trained operators, mechanics and labor to carry out the works. The Engineer shall have the right to expel any operators, mechanics or labor and to instruct suitable replacement thereof at any time he deems such action is necessary.

403.08 TRUCKS

Trucks for transport of the mix should be of tight construction, to prevent the loss of material and the excessive loss of heat. Provide each truck with a tarpaulin or other waterproof cover mounted in such a manner that it can cover the entire load when required. When in place, overlap the waterproof cover on all sides so that it can be tied down. Equip the trucks with chains on the tail gates to limit the size of the opening while under loading into the paver.

404 - ASPHALTIC CONCRETE
(For Cement Modified Aggregates see Clause 411)

404.01 DESCRIPTION

This work shall consist of constructing an asphaltic concrete base, binder, leveling and wearing paving courses on a prepared surface in accordance with these Specifications and in conformity with the lines, grades, thicknesses and typical cross-sections shown on the Drawings or directed by the Engineer. The general requirements of Clauses 401 to 403 of these Specifications shall apply to this work except where modified herein.

404.02 DESIGN REQUIREMENTS FOR ASPHALTIC CONCRETE

404.02.1 Materials

The materials used in asphaltic concrete mixes shall meet the following requirements of these Specifications:

Fine Aggregate	Clause 402.01
Coarse Aggregate	Clause 402.02
Commercial Mineral Filler	Clause 402.03
Asphalt Cement	Clause 402.04

Bitumen Modifier and Modified Bituminous Material	Clause 402.05
Liquid and Emulsified Asphalt	Clause 402.06
Hydrated Lime	Clause 402.07

404.02.2 Types of Asphaltic Concrete Mixes

The types of asphaltic concrete mixes shall be as specified on the Drawings and shall conform to the compositions shown in Table 404.02.2 except that modifications may be made to the asphalt cement minimum given in Table 404.02.2 subject to the design mix using imported Gabbro aggregates.

A minimum of 1.5% hydrated lime (by weight of total aggregate) may be added to all types of asphaltic concrete mix aggregates in accordance with Clause 403.02.2c of these Specifications. The actual amounts of hydrated lime, if added, and water to be added shall be established in the approved Job Mix Design.

A minimum of 40% of the fine aggregate used in Type III (Wearing Course) mixes shall be crushed sand.

The proportion of mineral filler used in any mix shall be not less than 3% nor greater than 5% by weight of the total aggregate.

The aggregate materials for asphaltic concrete (including coarse aggregate, fine aggregate and mineral filler) shall be combined so as to be well graded within the limits given in Table 404.02.2 of these Specifications. Combined gradations which, approach maximum limits on some sieves and minimum limits on other sieves are not acceptable.

The fine aggregate shall not contain more than 20 percent natural sand by weight of total aggregate.

Percent by Passing Weight

Sieve Size	Type I Base Course	Type II Binder or Leveling Course	Type III Wearing Course	Type IV Wearing Course
1-1/2 inch	100	-	-	-
1 inch	72 - 100	100	-	-
3/4 inch	60 - 89	82 - 100	100	-
1/2 inch	46 - 76	60 - 84	66 - 95	100
3/8 inch	40 - 67	49 - 74	54 - 88	80 - 100
No. 4	30 - 54	32 - 58	37 - 70	55 - 75
No. 8	22 - 43	23 - 45	26 - 52	35 - 50
No. 16	15 - 36	16 - 34	18 - 40	-
No. 30	10 - 28	12 - 25	13 - 30	18 - 29
No. 50	6 - 22	8 - 20	8 - 23	12 - 25
No. 100	4 - 14	5 - 13	6 - 16	8 - 18
No. 200	2 - 8	4 - 7	4 - 10	4 - 10
Asphalt Cement (% by weight of Total Aggregate)	3.0 - 4.5	3.5 – 5.0	4.0 – 5.5	4.5 – 6.0

(Hydrated lime can be added to all mixes, and the final gradation shall meet the above gradation envelopes)

Table 404.02.2 – Composition of Asphaltic Concrete Mixes

Conformance to gradation requirements will be determined on the extracted aggregate in accordance with AASHTO T30. The bitumen content shall be determined in accordance with AASHTO T164.

404.02.3 Mix Design Criteria

The Marshall Method of Mix Design (Asphalt Institute Manual Series MS 02) will be used in designing the asphaltic concrete mixes. Mechanically operated compaction equipment shall be used. The indicated number of blows is for equipment which rotates the sample during compaction. Additional blows giving equivalent results will be necessary for a compaction unit having stationary base which does not rotate the sample during compaction. All of the criteria shown in Table 404.02.3, not stability alone, shall be considered in designing and

evaluating each type of mix. The optimum bitumen content determined by the Marshall Method shall be used in prepared specimens for the Effect of water on cohesion of compacted bituminous mixtures (AASHTO T165) test.

Description	**Type I Base Course**		**Type II Binder or Levelling Course**		**Types III, IV Wearing Course**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
Marshall Specimens -AASHTO T 245 No. of Comp. Blows, each end of specimen	75		75		75	
Stability, kg	1600	-	1700	-	1800	-
Flow, 0.25mm	8	14	8	16	8	16
VMA	12	-	13	-	14	-
Air Voids, %	3	8	3	8	4	6
Aggregate Voids Filled With Bitumen, %	55	70	59	72	63	75
Immersion Compression Specimen (AASHTO T165) Index of Retained Strength (I.C.R.), % [I.C.R. should meet the requirement of the modified cement coated asphalt mixes according to Clause 411.02.2]	90	-	90	-	90	-
% Air voids at refusal, %	2	-	2	-	2	-

Table 404.02.3 – Design Criteria for Asphalt Concrete Mixes

Prior to final approval, the proposed job mix shall be compacted to refusal (i.e. to 500 blows), and the resulting voids in the mix shall not be less than 2%.

When tested for resistance to water damage in accordance with AASHTO T283 “Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage”, the conventional and polymer modified bituminous wearing course mixtures shall have a retained tensile strength greater than or at least equal to 80%.

404.02.4 Job Mix Formula and Allowable Tolerance

The Contractor shall submit for approval a proposed Job Mix Formula together with all applicable design data at least one month prior to commencement of the work. The Job Mix Formula will give a combined gradation showing a single definite percentage passing each sieve as well as a percentage of each material to be used in the mix. The Job Mix Formula will also establish the mixing temperature and a compaction reference density.

No asphalt works will be allowed to commence before the Contractor receives written approval from the Engineer for his Job Mix Formula.

The Engineer will test the job mix at least twice daily during plant operation and, if necessary, direct the Contractor to readjust the plant to conform to the Job Mix Formula. If, due to differing cold feed or hot bin gradations, the Contractor cannot consistently produce a mix meeting the approved Job Mix requirements, production shall cease, the Job Mix shall be redesigned and reapproved and the plant readjusted to produce a new Job Mix.

The Job Mix Formula may be amended as a result of experience in the execution and/or performance of the permanent asphalt works. Such an amendment may be submitted by the Contractor for the Engineer’s approval in which case the Contractor shall submit full details of the proposed amendment together with such data as is necessary to support his submittal. Amendment may also be directed by the Engineer.

The Contractor shall not be entitled to any increase in cost or extension of the Contract Period as a consequence of any amendment to the Job Mix Formula.

Approval by the Engineer of the Job Mix Formula shall in no way relieve the Contractor of his responsibilities and obligations stipulated in the Contract, and the Contractor shall be responsible for the soundness of the asphalt paving mixes and the satisfactory execution and performance of the asphalt paving courses.

In order to meet the requirements, an approved additive such as Portland cement, hydrated lime or liquid anti-strip agent, may be required in the Job Mix. Portland cement shall meet the requirements of AASHTO M 85. Hydrated lime shall meet the requirements of ASTM C 207, Type N. Cement or hydrated lime will normally be required in the approximate range of 2-3% by weight of the aggregates and shall be added at the cold feed in dry or slurry form as directed. Liquid anti-striping agent, if needed, will normally be required in the approximate range of 0.6-1.0% by weight of the bitumen, or according to the manufacturer's specifications.

After the Job Mix Formula has been established and approved, all mixes furnished shall conform thereto within the following tolerances:

Passing Sieve No. 4 and Larger	± 5.0%
Passing Sieves between No. 4 and No. 200	± 4.0%
Passing Sieve No. 200	± 1.0%
Asphalt Cement	± 0.3%
Temperature of Mix when emptied from mixer	± 10^{o}C

Any deviation from these limits shall be made only with the approval of the Engineer.

404.02.5 Sampling and Testing of Asphaltic Concrete Mixes

Samples of loose asphaltic concrete mix shall normally be taken behind the paver before compaction and shall be obtained in accordance with AASHTO T-168. Samples of compacted asphaltic concrete shall be obtained by coring in accordance with Method B of AASHTO T230. Determination of Bitumen Content and Extraction Gradation may be performed on either loose or compacted samples in accordance with AASHTO T164 (or T308) and AASHTO T30 except that the mass of mineral matter in the total volume of the extract shall be determined using a bituminometer or other equipment and procedures which give equally satisfactory results. The presence of a satisfactory amount of hydrated lime will be determined in accordance with the Ministry of Public Works "Test Procedure for Detection of Hydrated Lime in Loose Asphalt Mixes or Cores". The specific gravity of the compacted asphalt concrete cores will be measured in accordance with AASHTO T230.

Sampling and testing shall conform to the requirements of the relevant Clauses of the specification and Table 404.02.5.1 below.

The Marshall bulk specific gravity shall be determined in accordance with AASHTO T 166. The Marshall specimens shall be prepared from the same material used in construction, taken from samples of fresh bituminous mix at the mixing plant or from trucks delivering mix to the Site. Oven heating for up to 30 minutes to maintain the heat of the sample is permissible.

The bulk specific gravity of the mix as placed and compacted in situ shall be determined from 100 mm nominal diameter core samples, or slab samples cut from each compacted layer on the road at locations designated by the Engineer who may require additional tests to determine limits of areas deficient in density, or for recheck.

Samples for in situ bulk specific gravity determinations shall be taken in sets of 2 from each pavement location. Minimum frequency of sampling for each bituminous layer shall be one set/lane/500 m, with a minimum of one set per day of placing bituminous layers.

The Contractor shall cut the samples with an approved core drill in the presence of the Engineer. The equipment shall be capable of cutting the mixture without shattering the edges or otherwise disturbing the density of the specimen.

The Contractor shall, when necessary, furnish and apply cold water, ice, or other cooling substance to the surface of the pavement to prevent the sampling from shattering or disintegrating. The Contractor shall fill and compact all test holes at his own expense.

Frequency of Tests Required				
(A)			(B)	
Work item	Tests at Source of material	Frequency for all tests mentioned under (A)	Tests at road site	Frequency for all tests mentioned under (B)
4-1 Materials used in bituminous mix (at batching plant)	1. Specific Gravity & water absorption	- Test for each source - When materials quality changes - As requested		
	2. Abrasion Test			
	3. Chert Content			
	4. Clay Lumps & friable materials			
	5. Flaky and elongated particles			
	6. Soundness			
4-2 Materials used in bituminous mix (from hot bins)	1. Gradation	- Test for each source - When materials quality changes - As requested		
	2. Specific gravity and water absorption			
	3. Plasticity index			
	4. Sand equivalent			
	5. Stripping with asphalt			
	6. Aggregate Impact Value (A.I.V.)			
	7. Aggregate Crushing Value (A.C.V.)			
4-3 Bituminous mix design for each course (from hot bins)	1. Complete mix design in accordance with American Asphalt Institute (MS2)	- For each project -When results are not consistent with the mix design results		
	2. Loss of stability	-As requested		
4-4 Bituminous Mix Marshall stability for each layer	At Batching plant			
	1. Stability	- 1 Test each working day - Test for each batching plant - As requested	1. Stability	- 1 Test each working day - Test for each batching plant - As requested
	2. Flow		2. Flow	
	3. Extraction (binder content & gradation)		3.Extraction (binder content & gradation)	
	4. Air voids		4. Air voids	
	5. Voids in mineral aggregates		5. Voids in mineral aggregates	
	6. Daily Marshall density		6. Daily Marshall density	
	7. Loss of Stability	- Test each 3 working days	7. Road density & thickness (after final compaction)	-Test each 200 lin.m., per lane and for batch layer - As requested
			8. Loss of Stability	- Test each 3 working days - As requested

Table 404.02.5.1: Frequency of Testing for Bituminous Pavement

404.02.6 Construction of trial sections

Immediately prior to finalization of the Job Mix Formula, the Contractor shall lay trial sections of the various bituminous mixes intended for use in the Works. Each trial section shall be 2 lanes wide by 50 m long at approved locations close to the Site. Each trial section shall be laid using the same materials, proposed Job Mix, mixing, spreading and compaction plant and spreading and compaction procedures, proposed for use in the Works.

Each trial section shall serve as a field verification of the Job Mix design. The mix density achievable and the air voids at that density shall be determined and, if less than required, the Job Mix Formula shall be adjusted accordingly.

Each trial section shall also demonstrate the adequacy of hauling, spreading and compaction equipment and the suitability of the construction methods and organization proposed.

If the trial section meets the required specification, the Job Mix Formula will be approved.

The trial section shall be carried out at the Contractor's expense and is to be removed from Site, if required by the Engineer.

404.03 CONSTRUCTION REQUIREMENTS FOR ASPHALTIC CONCRETE

404.03.1 Weather Limitations

Production and spreading of asphaltic concrete mix shall not be permitted when the ambient temperature is less than 8°C (46°F), nor during rain, fog, dust-storms or other unsuitable weather.

404.03.2 Equipment Required

The equipment required for construction of the asphaltic concrete courses shall include but not be limited to the equipment listed in Clauses 403.01 through 403.08 of these Specifications, together with such miscellaneous equipment and tools as required for the satisfactory preparation and performance of the work. All equipment shall be checked and/or calibrated and approved by the Engineer prior to use. The equipment shall be satisfactorily maintained and shall be used in an approved manner to produce asphaltic concrete pavements in accordance with these Specifications. Adequate equipment and labor shall be used so that there is continual production and distribution of the asphalt course being constructed.

404.03.3 Survey and Preparation of Area to be Paved

The area to be paved shall be true to line and grade and shall have a properly prepared surface prior to the start of paving operations and shall be in conformity with the conditions and specifications pertaining thereto. Subbase and base surfaces shall be prepared to meet the appropriate specified compaction and surface tolerance requirements.

When an asphaltic concrete pavement course is to be placed on top of an existing pavement, the existing pavement surface shall be thoroughly cleaned from any broken, soft or unstable material and shall be prepared in accordance with Clause 407 of these Specifications.

Priming or tacking of surfaces to be paved shall be in accordance with Clause 405 or Clause 406 of these Specifications. No bituminous mix shall be laid on a prime or tack coat until it has been inspected and approved.

The surface of kerbs, vertical faces of existing pavements and all structures in actual contact with asphalt mixes shall be painted with a thin and complete coating of tack coat as instructed by the Engineer to provide a closely bonded, watertight joint.

All openings or structures in the road for water, drainage and other specified utilities shall be constructed and their positions and levels determined before the start of paving operations.

All utility trenches, cut in the bituminous road surfaces shall be backfilled, compacted and prepared, all in accordance with Clause 407 of these Specifications.

404.03.4 Preparation of Asphalt Mixes

A. Preparation of Asphalt Cement

The 60/70 penetration grade asphalt cement shall be heated to a temperature to yield viscosities in the range of 170-200 centistokes when delivered to the mixer, as determined from the Temperature-Viscosity Chart of the product used. Asphalt cement shall not be used if foaming occurs nor shall it be heated above 170°C at any time.

B. Preparation and Handling of Mineral Aggregate

Coarse and fine aggregate shall be stored at the asphalt plant in such a manner that the separate stockpiles will not become intermixed. The stockpiles shall be of sufficient size to provide a minimum quantity of one week's continuous production of asphalt mix. Aggregates brought to the asphalt plant to supplement stocks should be tested and approved prior to placing in the existing approved stockpiles.

The cold bins shall be calibrated with the materials to be used and the settings shall be such as to produce a combined gradation in accordance with the Job Mix Formula.

If required the hydrated lime additive system shall be calibrated and set to add the required amounts of hydrated lime and water. After the aggregates, water and hydrated lime have been thoroughly mixed, they shall be fed to the asphalt plant drier.

The materials shall be thoroughly dried and heated so that their temperature is within 8°C (15°F) of the temperature needed to satisfy the viscosity requirements of the asphalt cement. In no case shall the materials be introduced into the pugmill with a temperature, including the 8°C (15°F) tolerance permitted, of more than that at which the asphalt cement has a viscosity of 170-200 centistokes. The moisture content of the heated and dried materials shall not exceed 1.0%. The quantity of materials fed through the drier shall in all cases be held to an amount which can be thoroughly dried and heated within the limits specified.

The heated materials shall be screened into sizes such that they may be combined into a gradation meeting the requirements of the Job Mix Formula and the hot aggregate storage bins shall be such as to minimize segregation and loss of temperature of aggregate. Hot bins shall be drawn and cleaned of material at the end of each day's operation.

C. Proportioning and Mixing

The heated ingredients together with the mineral filler and asphalt cement shall be combined in such a manner so as to produce a mixture which complies with the requirements of the Job Mix Formula. Plant settings, once established, shall not be changed without the approval of the Engineer.

The temperature of the aggregate immediately prior to mixing shall be within +8°C (15°F) of the temperature of the asphalt cement and the temperature of the aggregate and asphalt prior to mixing shall be approximately that of the completed mix as defined in the Job Mix Formula approved by the Engineer. The mix temperature shall be within the limits set out in the Job Mix Formula when emptied from the mixer but in no case shall exceed 171°C (340°F).

Immediately after heating, the aggregates shall be screened into at least 3 sizes and conveyed into separate bins ready for batching and mixing with the bitumen. When the aggregates furnished are of such size and grading that separating into 3 bins is impractical, the number of required separations may, if approved, be reduced to 2 only. Screening operations shall produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates that are reasonably uniform and will result in the production of a mix conforming to the Job Mix requirements.

The dried and heated aggregate and (cold) mineral filler shall be combined in the plant in the proportionate amounts as determined by the Job Mix. Just prior to bitumen entering the mixer, bitumen modifier or anti-stripping additive, if required, shall be thoroughly mixed with the bitumen which shall then be introduced into the pugmill mixer in the proportionate amount determined by the Job Mix.

Mineral filler, in a cold dry state shall be proportional into the mixer either with the aggregate or after the introduction of the asphalt cement to avoid loss of fines that may occur in dry mixing as a result of turbulence in the mixer.

When anti-stripping additive is required the additive device shall be calibrated and set so that the specified amount of anti-stripping additive is thoroughly mixed with the bitumen just prior to entering the pugmill.

D. Control of Mixing Time

In batch type plants a dry mixing period of not less than four seconds shall precede the addition of the asphalt cement to the mix. Excess wet mixing shall be avoided. Wet mixing shall continue as long as is necessary to obtain a thoroughly blended mix but shall not exceed 75 seconds nor be less than 30 seconds.

The Contractor shall propose the length of time for both dry and wet mixing for the approval of the Engineer. Approval of the lengths of time for mixing shall not relieve the Contractor of his responsibilities and obligations under the Contract.

Once approved, mixing times shall not be altered unless so ordered or further approved by the Engineer.

In continuous type plants, the weights shall be determined for the job from tests made under the supervision of the Engineer and the determination of mixing time shall be by weight method under the following formula unless otherwise required:

Mixing time (sec.) = Pugmill Dead Capacity (kg.) divided by Pugmill output (kg. per sec.)

The maximum mixing time in batch or continuous type plants shall be limited as directed by the Engineer to avoid undue changes in the characteristics of the asphalt material.

404.03.5 Delivery of the Asphalt Mixes

Sufficient plant capacity, haul vehicles and storage shall be provided so that adequate supplies of mixture are delivered to ensure continuous paving can be achieved.

The dispatching of the hauling vehicles to the job site shall be so scheduled that all material delivered may be placed in daylight, unless the Engineer approves the use of artificial light. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

All precautions shall be taken to protect the mix from the weather during transit and whilst waiting to discharge.

The mix shall be delivered to the paver at a temperature between 145^{o}C and 165^{o}C. Should a significant proportion of the mixture delivered to the paver fail to meet this requirement, or should cold lumps be found in the mixture, the Engineer shall order that paving operations be suspended until measures are taken, to the approval of the Engineer, to ensure that these Specifications can be complied with.

404.03.6 Setting out and Reference lines

The Contractor shall survey the centerline profile and crown of the existing surface or base and determine a reference grade line which will be submitted for approval. A reference line of wire or suitable cord shall be installed at a uniform grade parallel to the approved reference grade line such that conformance with the required geometrics, surface tolerance and minimum thickness requirements shall be ensured. The reference line shall be supported at 8 m maximum spacing unless there is noticeable sag in the line or the pavement surface, in which case the maximum spacing shall be 4 m.

The reference line shall be maintained taut and free from sags at all times during spreading and initial compacting operations.

Except where the paver is matching a previously placed layer, a wire or cord reference line shall be installed on both sides of the paver for the initial bituminous course being laid. Thereafter only one reference line will normally be required, if the paver is equipped with adequate automatic super elevation control.

404.03.7 Spreading and Finishing

Spreading and finishing equipment conforming to the Clause 403.04 of these Specifications shall be used. The mix shall be laid upon an approved surface and only when weather conditions are suitable and in accordance with Specifications. Upon arrival at the point of use, the asphalt mix shall be spread and struck off to the grade, elevation and cross-section shape intended, either over the entire width or over such partial width as may be required. If the mix does not conform to the requirements, it shall not be used but shall be discarded.

Bituminous mixes shall be laid only when the air temperature is at least 5 degrees C or above, when the existing surface is free from moisture, and when the weather is not foggy, rainy, dusty or excessively windy (particularly at low temperatures).

Paving shall not be allowed in a greater width than 4 meters unless otherwise agreed by the Engineer.

For actual batching plant outputs up to 350 tonnes/hour (averaged on a daily basis) only one paving machine shall be operated at any one time.

Where actual plant output exceeds 350 tonnes/hour (averaged on a daily basis) a second paver may be operated subject to the approval of the Engineer.

Whilst paving is in progress on the Contract, the output of the batching plant shall be exclusively reserved for the operations and no mixture shall be supplied to other sites or projects.

If during laying, the paver is repeatedly delayed because of lack of mixture or if the paver stands at one location for more than thirty minutes (for any reason), a transverse joint shall be constructed in accordance with Clause 404.03.8a of these Specifications. Paving shall not recommence until the Engineer is satisfied that paving will proceed uninterrupted and until at least four loaded vehicles have arrived at the paving site.

The asphalt course shall be constructed to proposed levels and shall be homogeneous, providing after compaction an even surface free from undulations, rises or depressions, and within the tolerances stipulated. In no case shall construction of a new asphaltic concrete course (Type) begin until the previously laid course has been tested and approved in accordance with the Specifications.

When the same asphalt course (Type) is to be laid in more than one layer, the second layer shall be placed as soon as practicable after the first layer has been finished, rolled and cooled, and the Engineer may at his discretion request cleaning of the first layer and the application of a thin tack coat thereon if he so deems necessary.

Bituminous mix shall be spread in one or more layers so that, after rolling, the nominal thickness of each layer of the compacted bituminous material does not exceed 2 to 3 times maximum size of aggregate. This maximum thickness may be increased slightly when such increase is more appropriate to total pavement thickness and provided the Engineer determines that such increased thickness will not be detrimental to the quality of the finished bituminous course, and the Contractor can show that the required density is attained throughout the layer thickness.

Transverse joints in succeeding layers shall be offset at least 2 meters. Longitudinal joints shall be offset at least 150 mm.

The use of motor graders or hand spreading of the asphalt mix shall not be permitted except in places where it is impractical to use pavers and shall be only with the specific permission of the Engineer. The asphalt mix shall comply with all conditions regarding trueness of level, thickness and homogeneity of the mix.

Automatic electronic screed controls shall be required on all pavers and shall be used with a 9 meter articulated averaging beam or grade wire control as approved by the Engineer.

404.03.8 Compaction

Rolling equipment for use in compacting asphalt mixes shall meet the requirements of Clause 403.05 of these Specifications or be approved by the Engineer based on satisfactory results from the rolling trials required by this specification. At least three rollers shall be required at all times: one self-propelled pneumatic-tyred and two steel wheeled rollers. As many additional rollers shall be used by the Contractor as necessary to provide specified asphalt course density and surface characteristics in an orderly, efficient and continuous manner.

Prior to commencing construction of the permanent works, unless otherwise agreed with the Engineer, the Contractor shall carry out compaction trials for each type and thickness of asphaltic course to establish an approved rolling/compaction procedure which shall then be used as a minimum requirement for the compaction of the permanent works unless otherwise directed or agreed by the Engineer.

The compaction trials shall involve all procedures specified for the permanent works including testing as specified for the asphaltic course under consideration and any equipment, processes or procedures proposed by

the Contractor which are not included as a part of these Specifications. Construction of the permanent works shall not commence until a rolling/compaction procedure has been approved in writing by the Engineer. Such approval shall in no way relieve the Contractor of his responsibilities and obligations stipulated in the Contract.

The compaction trials shall not be measured or paid for separately but shall be considered an incidental obligation of the Contractor under this Section of the Specifications unless the Engineer agrees that the trials are conducted on a section of the permanent works and the Engineer approves the trial section(s) as acceptable to form part of the permanent works. In this case the material laid as the trial section(s) shall be measured and paid for in accordance with the Specifications.

Immediately after the asphalt mix has been spread and struck off, the surface shall be checked and any irregularities adjusted and then compacted thoroughly and uniformly by rolling.

To prevent adhesion of the mix to steel wheeled rollers, the wheels shall be kept properly moistened but excess water shall not be permitted.

After the longitudinal joints and edges have been compacted, rolling shall start longitudinally at the sides of the road and shall gradually progress towards the centre. On super-elevated sections, rolling shall begin on the low side and progress to the high side, overlapping on successive trips by at least one-half the width of tandem rollers and uniformly lapping each preceding track. The rollers shall move at a slow but uniform speed with the drive wheels nearest the paver. The speed shall not exceed 5.0 km/hr. for steel-wheeled rollers or 8.0 km/hr. for pneumatic-tyred rollers. The operating speed shall be approved by the Engineer.

The line of rolling shall not be changed suddenly or the direction of rolling reversed suddenly. If rolling causes displacement of the material, the affected areas shall be loosened at once with hand tools and restored to the original grade of the loose material before being re-rolled. Heavy equipment or rollers shall not be permitted to stand on the finished surface before it has been compacted and has thoroughly cooled.

When paving in a single width, the first lane placed shall be rolled in the following order:

a. Transverse joints
b. Longitudinal joints
c. Outside edge
d. Initial or breakdown rolling, beginning on the low side and progressing towards the high side.
e. Intermediate rolling
f. Finish rolling

When paving in echelon, 50mm to 100 mm of the edge which the second paver is following shall be left unrolled. Edges shall not be exposed more than fifteen minutes without being rolled. Particular attention shall be given to the construction of the transverse and longitudinal joints in all courses.

A. Transverse Joints

Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be checked with a straight-edge to assure smoothness and true alignment. Joints shall be formed with a bulkhead, such as a board, to provide a straight line and vertical face. If the joint has been distorted by traffic or by other means, it shall be trimmed to line and the face shall be painted with thin coating of emulsified asphalt before the fresh material is placed against it. To obtain thorough compaction of these joints, the material placed against the joint shall be tightly pushed against the vertical face with a steel-wheeled roller. The roller shall be placed on the previously compacted material transversely so that not more than 150mm of the rear rolling wheel rides on the edge of the joint. The roller shall be operated to pinch and press the mix into place at the transverse joint. The roller shall continue to roll along this line, shifting its position gradually across the joint, in 150 to 200 mm. increments, until the joint has been rolled with the entire width of the roller wheel. Rolling shall be continued until a thoroughly compacted, neat joint is obtained.

B. Longitudinal Joints

Longitudinal joints shall be rolled directly behind the paving operations. The first lane placed shall be true to line and grade and have a vertical face. The material being placed in the abutting lane shall then be tightly pushed against the face of the previously placed lane. Before rolling, the coarse aggregate in the material

overlapping the joint shall be carefully removed with a rake and discarded. Rolling shall be done with a steel wheeled roller.

The roller shall be shifted over onto the previously placed lane so that not more than 150 mm. of the roller wheel rides on the edges of the newly laid lane. The rollers shall then be operated to pinch and press the fine material gradually across the joint. Rolling shall be continued until a thoroughly compacted, neat joint is obtained.

When the abutting lane is not placed in the same day, or the joint is distorted during the day's work by traffic or by other means, the edge of the lane shall be carefully trimmed to line, cleaned and painted with a thin coating of emulsified asphalt before the abutting lane is placed.

The longitudinal joints in the surface course shall be along the same line as the traffic lane markers are to be placed.

C. Edges

The edges of the asphalt course shall be rolled concurrently with or immediately after rolling the longitudinal joint.

Care shall be exercised in consolidating the course along the entire length of the edges. Before it is compacted, the material along the unsupported edges shall be slightly elevated with hand tools. This will permit the full weight of the roller wheel to bear on the material to the extreme edges of the mat.

D. Breakdown Rolling

Breakdown rolling shall immediately follow the rolling of the longitudinal joints and edges. Rollers shall be operated as close to the paver as possible to obtain adequate density without causing undue displacement. In no case shall the mix temperature be allowed to drop below 120^{o}C prior to breakdown rolling. If the breakdown roller is steel-wheeled, it shall be operated with the drive wheel nearest the finishing machine. Pneumatic tyred rollers may be used as breakdown rollers.

E. Intermediate Rolling

Pneumatic-tyred rollers described in Clause 403.05 of these Specifications shall be used for the intermediate rolling. The intermediate rolling shall follow the breakdown rolling as closely as possible and while the paving mix is still of a temperature that will result in maximum density from this operation. Rollers shall be used continuously after the initial rolling until all of the mix placed has been thoroughly compacted. Turning of rollers on the hot paving mix which causes undue displacement shall not be permitted.

F. Finish Rolling

The finish rolling shall be performed with three-axle or tandem steel rollers unless otherwise permitted by the Engineer. Finish rolling shall be accomplished while the material is still warm enough for the removal of roller marks.

All rolling operations shall be conducted in close sequence.

In places inaccessible for the operation of standard rollers as specified, compaction shall be performed by manual or mechanical tampers of such design as to give the desired density.

After final rolling, the smoothness, levels, cross falls, density and thickness shall be checked and any irregularity of the surface exceeding the specified limits and any areas defective in texture, density or composition shall be corrected as directed by the Engineer, including removal and replacement at the Contractor's expense as directed by the Engineer.

404.03.9 Protection of the Asphalt Courses

Sections of the newly finished work shall be protected from traffic of any kind until the mix has been properly compacted and cooled. In no case shall traffic be permitted less than 12 hours after completion of the asphalt course unless a shorter period is authorized by the Engineer.

404.03.10 Testing and Acceptance of Completed Asphalt Concrete Courses

A. General

Each completed asphalt concrete course (Type) shall be tested and approved in accordance with the following requirements prior to placing any subsequent asphalt concrete course.

B. Sampling

The Contractor shall, at his own expense, cut samples from each completed asphalt course during the progress of the work and before final acceptance of the project, all as directed by the Engineer. Compacted samples shall be taken by coring in accordance with AASHTO T 230, for testing by the Engineer. Where the Contractor fails to provide cores as required by the Engineer, the Engineer may arrange for the taking of cores at the Contractor's expense. Samples shall be taken of the asphalt mix for the full depth of the course from the location directed by the Engineer at a rate of not less than one sample per 200 meter run of road or 2,000 square meters of paving whichever is less.

Whenever deficiencies are noted in loose mix samples or core samples, the Engineer may direct the taking of additional cores at the Contractor's expense in order to define the area of pavement involved.

Hot asphalt mix shall be placed and compacted in holes left by sampling.

C. Requirements for Compaction of Asphalt Concrete Courses

The degree of compaction determined in accordance with AASHTO T 230 is the ratio of the specific gravity of the pavement sample to the specific gravity of the laboratory Marshall specimens prepared in accordance with the Job Mix Formula. In-situ density can be determined for each layer of pavement using the Non-Destructive methods.

The minimum degree of compaction required for the various types of asphalt concrete, expressed as a percentage, shall be as follows:

Type of Mix	Minimum Degree of Compaction Required
Type I (Base Course)	95%
Type II (Binder or Levelling Course)	95%
Type III (Wearing Course)	97%
Type IV (Wearing Course)	97%

Should the specific gravity of samples cut from any asphalt concrete course fail to conform to the minimum required, this will be considered a major defect in the work on the basis of which the portion of the asphalt course represented by these samples shall be rejected.

D. Requirements for Asphalt Content, Gradation and Hydrated Lime

Should it transpire from the analysis conducted on samples of loose mix or cores that the asphalt content or aggregate gradation are beyond the permissible tolerances specified for the Job Mix Formula established for each respective asphalt course mix, or that a satisfactory quantity of hydrated lime ,if used, is not present, and that, as determined by the Engineer, such variation affects the characteristics of the asphalt mix as far as its conformity to the Contract Conditions and Specifications is concerned, this shall be considered a major defect in the work on the basis of which the portion of the asphalt course represented by these samples shall be corrected or removed and replaced at the expense of the Contractor, to the satisfaction of the Engineer and according to the Specifications.

E. Requirements for Construction Thickness and Pavement Levels

Each asphalt paving course (Type) shall be constructed to the lines, grades and thickness shown on the Drawings. The individual thickness of Type III asphalt layer shall not be less than that specified by more than 5 mm or more than 10% of the design thickness. The individual thickness of Types I and II asphalt layers shall not be less than that specified by more than 10 mm or more than 15% of the design thickness. The total thickness of bituminous courses shall not be less than that specified by more than 10 mm or more than 15% of the design thickness.

The Contractor shall compensate for minor deficiencies in the thickness of any bituminous course in the pavement structure by increasing the thickness of the subsequent bituminous course. After completion of the

final (wearing) course any deficiencies in the thickness of any course which have not been compensated for by increasing the thickness of a subsequent course, will be considered deficiencies in the final (wearing) course.

Cylinder core samples shall be taken as specified for in situ bulk specified gravity core samples.

Thickness of bituminous courses shall be determined by average caliper measurement of cores, rounded upwards to the nearest mm.

Paved sections to be measured separately shall consist of each 300 lin.m. section in each traffic lane. The last section in each traffic lane shall be 300 m plus the fractional part of 300 m remaining. Other areas such as intersections, entrances, crossovers, ramps, etc. shall be measured as one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.

One core shall be taken from each section by the Contractor at approved locations and in the presence of the Engineer. When the measurement of the core from any paved section is not deficient by more than 5 mm from the specified thickness, the core will be deemed to be of the specified thickness as shown on the Drawings.

When the measurement of the core from any paved section is deficient by more than 5 mm but not more than 10 mm, 2 additional cores spaced at not less than 100 m shall be taken and used together with the first core to determine the average thickness of such section.

When the measurement of the core from any paved section is less than the specified thickness by more than 10 mm, the average thickness of such section shall be determined by taking additional cores at not less than 5 m intervals parallel to the centerline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 10 mm. Exploratory cores for deficient thickness will not be used in average thickness determinations.

Any deficiencies in the total thickness of bituminous courses which are beyond the allowable tolerance limits, shall be made good by the Contractor as directed by the Engineer. Alternatively, the Contractor shall construct at his own expense, a surface course overlay, if practicable in the judgment of the Engineer. Any such overlay shall be a minimum of 40 mm compacted thicknesses and to the specified standard of the course it is overlaying.

The levels of the finished surface of asphalt courses shall be checked by the Contractor in the presence of the Engineer at maximum intervals of 10m and at intermediate points as directed. These levels shall not vary by more than +8 mm from the required levels in the case of bituminous base course and more than +6mm in the case of binder and wearing courses. In addition the variations in the falls to cross sections of the road shall not vary from the required values by more than 0.3%.

The tolerances herein specified shall not invalidate the tolerances set forth for the evenness of surface of the asphalt paving course.

F. Requirements for Evenness of Surface

The Engineer shall test the evenness of surface for each course of the various asphalt paving courses incorporated in the Contract to ascertain their conformity to the Conditions of Contract, Specifications and Drawings in respect of levels and longitudinal falls, to cross-sections and evenness of surface.

The Contractor shall put at the disposal of the Engineer a four (4) meters straight edge and a crown template of sturdy and approved design and enough labor to assist in the checking operations.

Any layer containing deviations or variations exceeding the following tolerances shall be corrected or removed and replaced, at the expense of the Contractor in accordance with the instructions and to the satisfaction of the Engineer.

When tested by a four (4) meters straight edge placed at right angles and parallel to the road centreline at intervals not exceeding two (2) meters, or when tested by a crown template placed at right angles to the road centreline at intervals not exceeding half the template length, variation of the surface of the road from the testing edge between any two contacts with the surface shall not exceed the following maximum tolerances:

Type I (Base Course)	8 mm
Type II (Binder or Leveling Course)	4 mm
Type III (Wearing Course)	4 mm

The tolerances herein specified for evenness of surface shall not invalidate the tolerances set forth for construction thickness and pavement levels of the asphalt paving courses.

G. Skid Resistance and Surface Texture

Surface Texture: The conventional and polymer modified bituminous wearing course layer shall have a texture depth of at least 0.8mm tested upon completion of pavement in accordance with the Sand Patch Test ASTM E 965.

404.04 MEASUREMENT AND PAYMENT

404.04.1 Method of Measurement and Basis of Payment of Asphalt Concrete Courses

Measurement of asphalt concrete courses (whether conventional or polymer modified) shall be by meter square for the various types and thicknesses required in accordance with the Drawings, Specifications or as directed by the Engineer and shall be calculated from the top surface area, excluding tapered edges which shall be included in the rates.

Payment for asphalt concrete Type I (Base), Type II (Binder or Leveling) and Type III (Wearing) course constructed in accordance with these Specifications shall be at the rate for the respective type of mix as shown in the Bills of Quantities. The rates shall be all inclusive of the materials, mixed, furnished spread, compacted, completed, tested and accepted, and of the equipment and labor necessary for the proper completion of the work in accordance with these Specifications.

Bituminous Prime and Tack coats shall be measured as prescribed under Clauses 405.04 and 406.05 respectively.

Where new road construction work adjoins or meets existing road construction, e.g. new shoulders and cross roads, no separate payment will be made for cutting back the edges of the existing construction to receive the new surfacing layers, the cost being deemed to be included with the cost of the new surfacing courses.

404.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
404.1	Bituminous Base Course – Type I (thickness)	sq.m
404.2	Polymer Modified Bituminous Base Course (thickness)	sq.m
404.3	Bituminous Binder or Leveling Course – Type II (thickness)	sq.m
404.4	Polymer Modified Bituminous Binder Course (thickness)	sq.m
404.5	Bituminous Wearing Course – Type III (thickness)	sq.m
404.6	Polymer Modified Bituminous Wearing Course (thickness)	sq.m

405 - PRIME COAT

405.01 DESCRIPTION

This work shall consist of furnishing and applying liquid asphalt and blotter material, if required, to a previously prepared and approved subgrade or granular base/sub-base course in accordance with these Specifications and to the full width shown on the Drawings or as directed by the Engineer.

405.02 MATERIAL REQUIREMENTS

405.02.1 Liquid Asphalt

Liquid asphalt shall be of the medium curing type MC-70 grades and shall conform to the requirements of the Specifications given in Clause 402.06 of these Specifications. The application rate shall be between 0.8 and 1.75 kg/m^2, as determined by the Engineer, based on the relevant trial sections.

405.02.2 Blotter Material

Blotter material, if required, shall be clean natural sand and shall conform to the requirements of the

Specifications given in Clause 402.01 of these Specifications.

405.03 CONSTRUCTION REQUIREMENTS

405.03.1 Weather Limitations

Prime coat shall not be applied when the ambient temperature is less than 10^{o}C nor during rain, fog, dust-storms or other unsuitable weather.

405.03.2 Application Temperature

The application temperature for the MC-70 liquid asphalt shall be between 45^{o}C and 80^{o}C as directed by the Engineer.

405.03.3 Equipment Required

The equipment used by the Contractor shall include an asphalt distributor in accordance with Clause 403.06 of these Specifications as well as a power broom and a power blower. Power broom shall be self-propelled and equipped with a cylindrical, rotating nylon bristle brush of not less than 760 mm in diameter and not less than 1800 mm in length. The brush shall be capable of being angled to the right and left with adjustable ground pressure. Where necessary for the proper preparation of the surface, motor graders, rollers and water trucks, etc. shall also be provided.

405.03.4 Construction of trial sections

The Engineer may, if he deems necessary, require trial sections to be constructed prior to the commencement of on Site prime coat applications. The Contractor shall construct trial sections using varying application rates of bitumen, as selected by the Engineer. Each trial section shall be 2 lanes wide by 50 m long, at approved locations on or close to the site.

Each trial section shall be constructed using the same materials, mixing and spraying equipment, and construction procedures, proposed for use in the Works.

The objectives of these trials shall be to determine the adequacy of the Contractor's equipment and to fulfill the specified application rates for cutback bitumen prime coats.

The Contractor shall not proceed with any Site coat applications until the methods and procedures established in the trials have been approved.

405.03.5 Surface Preparation

Immediately before applying the prime coat, all loose dirt, earth and other objectionable material shall be removed from the surface with a power broom of approved design and/or a power blower as required, and any ruts, soft or unacceptable irregularities in the surface spots shall be repaired in accordance with the instructions of the Engineer. If the Engineer so requires, the surface shall be lightly bladed and rolled immediately prior to the application of the prime coat, in which case brooming or blowing may not be required. The Engineer may direct that a light application of water be made just prior to the application of liquid asphalt to facilitate penetration. Priming will not be permitted when there is free water present on the surface.

405.03.6 Method of Operation

After preparing the road surface as above, the liquid asphalt shall be applied by means of the distributor at the temperature and rate directed by the Engineer. Hand spraying of restricted, inaccessible areas is permitted, subject to the approval of the Engineer.

The surface of structures, kerbstones and other appurtenances adjacent to areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

The prime coat shall usually be applied to 1/3 or 1/2 of the road width at a time. When applied in two or more lanes, there shall be a slight overlap of asphalt material along adjoining edges of the lanes. It should be noted that no overlapping is allowed at the transverse joints and that thick paper shall be used at the joint to protect the previous application and the joining application shall begin on the paper. The paper used shall be removed and satisfactorily disposed off by the Contractor after use. Care shall be taken that the application of bituminous

materials at the junctions of spreads is not in excess of the specified amount. Excess bituminous material shall be removed from the surface.

405.03.7 Maintenance and Traffic

Traffic shall not be permitted on the primed surface until the asphaltic material has penetrated and dried and, in the judgement of the Engineer, will not be picked up under traffic. If it becomes necessary to permit traffic prior to that time, but in no case sooner than 24 hours after the application of the asphaltic material, blotter material shall be applied as directed by the Engineer and traffic shall be permitted to use the lanes so treated. Blotter material shall be spread from trucks operated backward so that the wheels will not travel in uncovered wet asphaltic material. When applying blotter material to an asphalt treated lane that adjoins a lane that has not been treated, a strip at least 200 mm. wide along the adjoining edge shall be left devoid of blotter material in order to permit an overlap of asphalt material.

The Contractor shall maintain the primed surface in a good clean condition and prior to the application of the next course, any surface irregularities shall be corrected and all excessive blotter material, dirt or other objectionable materials shall be removed.

405.04 MEASUREMENT AND PAYMENT

405.04.1 Method of Measurement and Basis of Payment of Prime Coat

Measurement of prime coat for the various types (primed at the approximate rate approved by the Engineer) shall be by meter square as covered by the subsequent sand asphalt or asphaltic concrete layer or such other areas required in accordance with the Drawings, Specifications or as directed by the Engineer.

Payment for the prime coat constructed in accordance with these specifications shall be at the rate shown in the Bills of Quantities. The rate shall be all inclusive of the materials, equipment and labour necessary for the proper completion of the work.

405.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
405.1	Bituminous Prime Coat	sq.m

406 - TACK COAT

406.01 DESCRIPTION

This work shall consist of furnishing and applying diluted emulsified asphalt to a previously prepared base or road surface, to provide bond for a superimposed course, in accordance with these Specifications and to the full width shown on the Drawings or as directed by the Engineer.

406.02 MATERIAL REQUIREMENTS

406.02.1 Emulsified Asphalt

Liquid asphalt shall be of the rapid curing type RC-70 grade and emulsified asphalt shall be of the slow-setting Cationic or Anionic type of the CSS-1h or SS-1h grades respectively and shall conform to the requirements of Clause 402.06 of these Specifications. The approved emulsion will be diluted with approximately an equal quantity of water and thoroughly mixed as directed by the Engineer. The diluted emulsion or the cutback bitumen shall be applied at a rate between 0.15 to 0.75 kg/m2 as specified by the Engineer.

406.03 CONSTRUCTION REQUIREMENTS

406.03.1 Weather Limitations

Tack coat shall not be applied when the ambient temperature is less than 10^{o}C nor during rain, fog, dust-storms or other unsuitable weather.

406.03.2 Application Temperature

The application temperature for the diluted emulsified asphalt shall be between 25°C and 65°C, as directed by the Engineer.

406.03.3 Equipment Required

The Equipment used by the Contractor shall include an asphalt distributor in accordance with Clause 403.06 of these Specifications as well as a power broom and a power blower. Power broom shall be self-propelled and equipped with a cylindrical, rotating nylon bristle brush of not less than 760 mm in diameter and not less than 1800 mm in length. The brush shall be capable of being angled to the right and left with adjustable ground pressure. In addition, the Contractor shall supply and utilize efficient and approved equipment for diluting the emulsified asphalt with water.

406.03.4 Construction of trial sections

Tack coat trial sections shall be constructed following the same requirements and criteria as those specified for prime coat under Clause 405.03.4 of these Specifications.

406.03.5 Surface Preparation

The full width of the surface to be treated shall be cleaned with a power broom or power blower to remove dust, dirt or other objectionable materials. All fatty or unsuitable patches, excess cracks or joint filler and all surplus bituminous material shall be corrected in accordance with the instructions of the Engineer. The surface shall be dry when treated.

406.03.6 Method of Operation

Immediately after cleaning the surface, the diluted emulsified asphalt shall be applied by means of the distributor at the temperature and rate directed by the Engineer. Hand spraying of restricted, inaccessible areas is permitted, subject to the approval of the Engineer.

The surface of structures, kerbstones and other appurtenances adjacent to areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

After application, the surface shall be allowed to dry until it is in a proper condition of tackiness to receive the super-imposed course. Tack cost shall be applied only so far in advance of the super-imposed course placement as is necessary to obtain this proper condition of tackiness. Until the super-imposed course is placed, the Contractor shall protect the tack coat from damage.

If the tack coat is unavoidably damaged by rain or dust, it shall be allowed to dry, shall be cleaned again by a power-broom or power-blower and, if required by the Engineer, a subsequent light application of tack applied to the surface. No additional payment shall be made for this work.

Where, in the opinion of the Engineer, a tack coat is not necessary between layers of freshly placed courses, he may give instructions in writing to omit the tack coat, in which case there shall be no payment for tack coat for the areas concerned. Any cleaning required in these areas shall be considered to be included in the overlaying asphaltic concrete course and no separate payment will be made.

406.04 POLYMER MODIFIED TACK COAT

Polymer modified Tack Coat shall be hot applied over the prepared polymer modified or unmodified bituminous layers to receive the polymer modified bituminous layer, as and where indicated on Drawings. The polymer modified tack coat material shall be as specified in this Section of the Specification except that the original “base” binder (before polymer modification) shall be Penetration Grade Bitumen and the specification for the polymer modified bitumen binder shall be as specified under Clause 402.05 of these Specifications (unless otherwise specified hereunder in this Clause). The type of tack coat and its rate of application shall be compatible with the polymer modified bituminous layer that will be applied on top of it, to the satisfaction of the Engineer. The rate of application shall be between 0.25 and 0.5 kg./sq.m.

The viscosity of the binder used for the polymer modified tack coat (Brookfield viscosity determined as per ASTM D4402) at application temperature shall range between 200 and 400 CP. The Softening Point and Elastic Recovery at 25° C (after RTFOT) of the polymer modified tack coat shall not be less than 80° C and 90% respectively.

The polymer modified tack coat shall be applied at a temperature ranging from 180° C to 190° C.

406.05 MEASUREMENT AND PAYMENT

406.05.1 Method of Measurement and Basis of Payment of Tack Coat

Measurement of tack coat for the various types required (at the appropriate rate approved by the Engineer) shall be by meter square as required to be covered by subsequent asphaltic layers in accordance with the Drawings, Specifications or as directed by the Engineer.

In cases where the Contractor elects to place any sand asphalt or asphaltic concrete layer shown in the Documents to be in one layer, in more than one layer, then no measurement of tack coat shall be made at the interface between layers.

Payment for the tack coat shall be at the rate shown in the Bills of Quantities. The rate shall be all inclusive of the materials, equipment and labour necessary for the proper completion of the work.

406.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
406.1	Bituminous Tack Coat	sq.m
406.2	Polymer Modified Tack Coat	sq.m

407 - PAVEMENT REPAIRS

407.01 DESCRIPTION

This work shall consist of the various types of repairs to existing pavements and appurtenances described herein, necessary to correct structural failures, grade elevations, drainage and deterioration and/or to prepare the existing pavement surface prior to placing asphaltic concrete overlays or seal coats. This work shall be as shown on the Drawings or as directed by the Engineer.

407.02 MATERIALS AND EQUIPMENTS REQUIREMENTS

407.02.1 Materials Required for Pavement Repairs

The materials required for the various Pavement Repair Items shall be as specified and shall be in accordance with the requirements of Clause 402 of these Specifications. No separate payment for the materials used shall be made and their cost shall be included in the various Pavement Repair Items.

407.02.2 Equipment Required for Pavement Repairs

The Contractor shall be responsible to supply all the equipment and labour necessary to perform the work described for the various types of Pavement Repair Items in accordance with these Specifications and as directed by the Engineer. The major equipment shall conform to Clause 403 of these Specifications.

407.03 TYPES OF PAVEMENT REPAIRS AND THEIR CONSTRUCTION REQUIREMENTS

407.03.1 Repair of Potholes

(Isolated holes in asphaltic concrete pavements of less than 1.0 m^2)

The Contractor shall:

a. Cut the failed pavement back to solid material with pneumatic asphalt cutting tools. Make the cut square or rectangular with faces straight and vertical. One pair of faces shall be at right angles to the direction of traffic.

b. Remove the cut pavement and loose unsuitable material from the hole and cart away and dispose at a location designated by the Engineer/Municipality.

c. If soil is removed, fill the excavation with a Type 'C' sand-gravel as defined in Clause 303.02.3 of Section 3 (Sub-base and Base Courses) of these Specifications which has been premixed to optimum moisture content. Place the material in 150 mm. lifts and compact each lift to 95% modified Proctor Density with mechanical compactors; similar treatment is to be applied on subsoil before filling the excavation with sand-gravel.

d. Wire broom clean the cut edges of the pavement and paint with bituminous emulsion.

e. Prime the compacted soil or the upper surface of the sand-gravel with a light coating of MC-70 when directed by the Engineer.

f. Fill the hole with the appropriate hot asphaltic concrete mix and compact in lifts not exceeding 70 mm. to the same level as the adjacent surface. Vibratory compactors shall be used to compact the hot asphalt concrete.

g. Check level of the patch with a straight edge and make corrections as required.

407.03.2 Repair of Failed Pavement (Deep patch)

The Contractor shall:

a. Cut the failed pavement back to solid material with pneumatic asphalt cutting tools. Make the cut square or rectangular with faces straight and vertical. One pair of faces shall be at right angles to the direction of traffic. Patching works shall be limited to localized deficient areas as jointly determined by the Engineer and the Contractor. These areas are usually not exceeding 3m in length and one lane width. The distance between two individual patches shall be not less than 5m.

b. Remove the cut pavement and excavate the underlying soil to a depth of not less than 300 mm. The Engineer may, when deemed necessary, order substantially greater depths of excavation payable at Day work rates. Cart away and dispose all cut pavement and excavated soil at a location designated by the Engineer/Municipality.

c. Thoroughly compact the subsoil with mechanical compactors to 95% of modified Proctor Density (in the presence of the patch the optimum moisture content shall not be exceeded).

d. Fill the excavation to the bottom of the pavement with a Type 'C' sand- gravel as defined in Clause 303.02.3 of Section 3 (Sub-base and Base Courses) of these Specifications which has been premixed to optimum moisture content. Place the material in 150 mm. lifts and compact each lift to 95% modified Proctor Density with mechanical compactors.

e. Wire broom clean the cut edges of the pavement and paint with bituminous emulsion.

f. Lightly prime the compacted sand-gravel with MC-70 when directed by the Engineer.

g. Place and compact a Type II asphaltic concrete in the excavation in 70 mm. lifts to the same level as the adjacent surface. The lower lift shall be compacted with a vibratory compactor and the top lift shall be compacted with a steel wheeled roller by first compacting the hot asphalt concrete 150 mm. from the two traffic edges and then by rolling in the direction of traffic. The drive wheel of the roller shall be in a forward position. Use of an asphaltic concrete pavement finisher will depend on the size of the area being patched.

407.03.3 Repair of Depressed Pavement (Skin patch)

In cases where the pavement has depressed but the asphaltic concrete has not fractured and the pavement appears stable, the Contractor shall:

a. Cut and remove the upper 30 mm. of the pavement starting just behind the depression. Cart away and dispose of the removed pavement at a location designated by the Engineer/Municipality.

b. Wire broom clean the surface and lightly tack the surface and paint the edges of the cut with bituminous emulsion (not exceeding 0.23 litres per sq.m. of tack coat).

c. Fill the cut with the appropriate hot mix asphaltic concrete and compact with a steel wheeled roller by first

compacting the hot asphaltic concrete 150 mm. from the two traffic edges and then by rolling in the direction of traffic. The drive wheel of the roller shall be in the forward position.

d. Check the level of the patch with a straight edge and make corrections as required.

407.03.4 Repair of Utility Cuts

The Contractor shall:

Case I: In cases where the asphaltic concrete pavement is broken or cracked:

a. Cut the failed pavement back to solid material with pneumatic asphalt cutting tools. Make the cut rectangular with faces straight and vertical. One pair of faces shall be at right angles to the direction of traffic.

b. Remove the cut pavement and excavate the underlying soil to a depth of not less than 300 mm. The Engineer may, when deemed necessary, order substantially greater depths of excavation payable at Day work Rates. Cart away and dispose all cut pavement and excavated soil at a location designated by the Engineer/Municipality.

c. Thoroughly compact the sub-soil with mechanical compactors to 95% of modified Proctor Density (in the presence of patch, the optimum moisture content shall not be exceeded).

d. Fill the excavation to the bottom of the pavement with a Type "C" sand- gravel as defined in Clause 303.02.3 of section 3 (Sub-base and Base Courses) of these Specifications which has been premixed to optimum moisture content. Place the material in 150 mm. lifts and compact each lift to 95% modified Proctor Density with mechanical compactors.

e. Wire broom clean the cut edges of the pavement and paint with bituminous emulsion.

f. Prime the compacted sand-gravel with a light coating of MC-70 when directed by the Engineer.

g. Fill and compact the cut with the appropriate asphaltic concrete mix in lifts not exceeding 70 mm. to the same level as the adjacent surface. The lower lift shall be compacted with a vibratory compactor and the top lift compacted with a steel-wheeled roller by first compacting the hot asphaltic concrete 150 mm. from the two traffic edges and then by rolling in the direction of traffic. The drive wheel of the roller shall be in a forward position. Use of a vibratory compactor on the top lift shall be only with the permission of the Engineer.

h. A vibratory plate compactor shall be used to compact the hot asphaltic concrete against kerbing and gully inlets.

i. Check the level of the patch with a straight edge and make corrections as required.

Case II: In cases where the utility cut has been patched and the patch is depressed but the pavement is not fractured and the asphaltic concrete appears stable:

a. Cut and remove the upper 30 mm. of the pavement starting just behind the depression. Cart away and dispose of the removed pavement at a location designated by the Engineer/Municipality.

b. Wire broom clean the surface and lightly tack the surface and paint the edges of the cut with bituminous emulsion (not exceeding 0.23 litres per sq.m. of tack coat).

c. Fill the cut with the appropriate asphaltic concrete and compact with a steel wheeled roller by first compacting the hot asphaltic concrete 150 mm. from the two traffic edges and then by rolling in the direction of traffic. The drive wheel of the roller shall be in a forward position.

d. Check the level of the patch with a straight edge and make corrections as required.

407.03.5 Sealing Cracks in Asphalt Concrete Pavement

The Contractor shall:

a. Wire broom the surface of the cracked pavement

b. Blow out each crack with compressed air.

c. Cracks of 3 mm to 7mm width or wider shall be filled with clean, coarse sand; then saturated with 1:1 diluted emulsified bitumen, or as directed by the Engineer.

d. Fill cracks less than 3 mm in width with bituminous emulsion. Avoid overfilling the cracks or spilling the liquid asphalt on the surface. In areas of fine matrix cracking (cracks less than 3 mm wide) where adjacent cracks are closer than 150 mm the whole area shall be repaired in accordance with Clause 407.03.2 of these Specifications.

e. Scrape off any excess asphalt with a squeegee and sprinkle sand on the sealed crack.

407.03.6 Restoration of Kerbing

The Contractor shall:

a. Remove pavement and tiles adjacent to the kerbing and break the mortar joint between the sound kerbstone and the kerbstones to be removed or reset.

b. Remove all broken and loose kerbstone and rubble and chisel off the mortar from the exposed edges of the sound kerbstones.

c. Excavate the soil 300 mm. in back of the kerb line and to the depth of the foundation casting.

d. Clean and reinstate the foundation casting. This may need a raising for a maximum height of 150 mm. if so, the Contractor is to raise the foundation using a K 180 concrete casting with the same width of the existing foundation and the required height. The price of this work shall be included in the Contract Price of this clause and no claim of any nature concerning this work shall be accepted.

e. Wet the foundation casting and set and grout the replacement kerbstone to proper alignment allowing 10 mm. for mortar joints and 10 mm. for expansion joints.

f. Wet the joints and fill with a cement and sand mortar of 1:2 mix, clear point and cure with a liquid curing compound as directed by the Engineer.

g. Fill the expansion joints with Bituminised Celotex or equivalent material.

h. Frame and cast a 100 x 150 mm. Portland cement concrete toe against the front of the kerbstone using a K140 unreinforced concrete mix with a maximum aggregate size of 19 mm (3/4 inch). Cure with a liquid curing compound and as directed by the Engineer.

i. Cast a Portland cement concrete haunch of the K 180 concrete mentioned above to the back of the kerbstone extending a minimum of 100 mm. from the base of the kerbstone and tapering upward to a point 50 mm. below the top of the kerbstone. Cure with a liquid curing compound as directed by the Engineer.

j. Expansion joints mentioned above should be constructed each 10 meters in the new kerbing and in between new or reset kerbstone and sound kerbstone.

k. Strip all forms from the castings and fill the excavation in back of the kerbstone with soil to a depth 50 mm. below the top of the kerbstone.

l. Paint the face of the concrete and kerbstone which will be in contact with the asphaltic concrete with bituminous emulsion.

m. Reinstate the asphaltic concrete pavement and tiles adjacent to the repair.

407.03.7 Construction of Kerbcuts

Wherever needed (house entrances in residential areas, access to street shoulder, etc.) and according to the Engineer's instructions, kerbcuts shall be constructed by framing and casting a K 300 unreinforced concrete using Type III quick hardening Portland cement or using ordinary Portland cement and adding approved additives to the concrete in order to quick harden it. The Contractor whenever instructed to carry on the construction of kerbcuts shall:

Case I: In case of constructing kerbcuts in the place of existing kerbstone: Break and remove and dispose off the driveway (from the street to the shoulder). Break and remove pavement and/or tiles adjacent to the kerbcut if necessary.

Break and remove the required number of kerbstones, and chisel off the mortar from the exposed edges of the sound kerbstones and from the upper surface of the kerbstone concrete foundation (if kerbstones to be removed have a front concrete casting and/or a back concrete haunch, these are to be broken and removed also).

Case II: In case of constructing kerbcuts in locations where existing kerbstone is not built or is broken, cut and excavate to the level of the existing kerbstone foundation or to the upper surface level of the adjacent kerbstone foundation including and/or breaking and removing all obstacles obstructing the construction of kerbcuts (adjacent asphalt pavement, etc.) (In case of existing kerbstone foundation, carry on as described in Case I, in case of construction on soil: grade, sprinkle and compact the soil and then proceed as described in Case I).

a. Excavate the soil 300 mm. in back of the kerb line and to the depth of the foundation casting.

b. Frame and cast the required kerbcut as per the specifications given above for the concrete and as per the dimensions and shape shown on the Drawings. The maximum size aggregate for the concrete should be 19 mm (3/4 inch). The concrete shall be cured with a clear liquid curing compound and as directed by the Engineer. The back of the kerbcut should be in line with the back of the existing kerb line. A gap of 10 mm shall be provided between each end of the kerbcut and the adjacent sound kerbstone for the construction of expansion joints.

c. Strip all form from the casting.

d. Fill the expansion joints with Bituminised Celotex or equivalent material.

e. Paint the surface of the kerbcut which will be in contact with the asphalt concrete pavement with bituminous emulsion.

f. Fill, grade and compact the excavated space behind the kerbcut to the required level.

g. Reinstate the asphaltic concrete pavement and/or tiles adjacent to the kerbcut.

h. Dispose off the debris resulting from the operation at locations designated by the Engineer/Municipality.

i. Grade the area between the kerbcut and the entrance of the house, add or cut fill to give a slope of 2% towards the kerbcut, sprinkle and compact.

407.03.8 Restoration of Concrete Tile/Block

The Contractor shall:

a. Remove carefully the concrete tiles/blocks, clean, chisel off the mortar from the exposed faces, protect, load, transport and unload the sound and unbroken tiles/blocks at locations designated by the Engineer. The removal of the concrete tiles/blocks shall be by hand, so as to preserve the tiles/blocks.

b. Cart away and dispose off the remainder of the tiles/blocks to a location designated by the Engineer/Municipality.

c. Break, remove and cart away the mortar or any concrete base laid below the tiles/blocks to the designated location.

d. Excavate the foundation soil to a depth of 50 mm; cart away and dispose off at a location designated by the Engineer/Municipality, level, sprinkle with water, add filling if needed to bring the level of the soil to 100 mm. below the top level of the new tiles/blocks, if filling is added, add water too, turn over and mix the soil thoroughly, compaction operation shall then commence until a minimum of 90% of the maximum dry density is attained, taking into consideration that the leveling of the natural ground surface shall be done according to the proposed grades and slopes and that any objectionable material and unsuitable soil shall be removed from the site.

e. A layer of clean sand, average 50 mm. thick shall be spread and water shall be added in order to obtain the sought grades and levels before placing the concrete tiles/blocks.

f. Precast concrete tiles/blocks shall be placed directly on the sand layer without using any cement mortar.

g. In placing concrete tiles/blocks, care must be exercised so that no spaces shall be left between tiles/blocks, sides of tiles/blocks shall be touching each other as close as possible.

h. Tiles/blocks shall be secured in place using light compactors in order to achieve the proposed levels and grades.

i. Thin layer of sand shall be utilised as filler between lines. Water shall be sprayed to affix the sand in the voids.

j. Placing of tiles/blocks shall be carried out in lengths not exceeding 10 meter runs separated by expansion joints of pieces Bituminised Celotex 10 mm. thick unless otherwise instructed by the Engineer.

k. Concrete tiles/blocks shall be placed in a proper pattern, no tiles/blocks or any part thereof shall be cast in-situ.

l. Additional or substitute pattern, if needed, can be used for laying tiles only after a written approval from the Engineer is obtained.

407.03.9 Adjustment of Gully Inlets or Manholes to New Pavement Elevation

The Contractor shall:

a. Barricade the immediate work site to protect workmen and motorists without closing the entire carriageway lane to traffic.

b. Cut and remove sufficient asphalt pavement and Portland cement concrete from the edges of the gully frame or manhole to permit removal of the frame from the gully or manhole roof without damaging the reinforcing steel and cart away and dispose of the rubble at site designated by the Engineer/Municipality.

c. Position the gully or manhole frame at the proper elevation and cast it in place with K 300 concrete using Type III quick hardening Portland cement (or using ordinary Portland cement and adding additives approved by the Engineer to quick harden the concrete).

d. To cure the concrete paint the exposed surface with bituminous emulsion after the initial set but never later than twenty minutes after placing the concrete. Curing period to be designated by the Engineer.

e. Clean the inside of the gully or manhole and replace the gully grate or manhole cover.

407.03.10 Removal of Driveway Approaches

Approaches from the shoulder of the road to the pavement constructed from asphalt mixes, concrete or whatever should be demolished and removed by the Contractor prior to commencing the works in the road and any damage caused by the operation should be repaired by the Contractor.

407.04 MEASUREMENT AND PAYMENT

407.04.1 General

Measurement for the various specified Pavement Repairs shall be as described below. Payment shall be made under Section 4 (Asphalt Works) of the Bills of Quantities and rates for the various items shall be full compensation for all operations necessary to complete the works in accordance with the Specifications. No separate measurement will be made for excavation, prime or tack coats, pavement materials, subgrade, subbase, or base courses.

407.04.2 Repair of Potholes

Measurement shall be by number of potholes repaired, regardless of size.

407.04.3 Repair of Failed Pavement

Measurement shall be by meter square of failed pavement repaired.

407.04.4 Repair of Depressed Pavement

Measurement shall be by meter square of depressed pavement repaired.

407.04.5 Repair of Utility Cuts

Measurement shall be by meter square of utility cuts repaired, for case I work and case II work.

407.04.6 Sealing Cracks in Asphaltic Concrete Pavement

There shall be no measurement or payment for this work item which shall be considered as a subsidiary obligation to paid items under this Section of the Specifications.

407.04.7 Restoration of Kerbing

Measurement shall be by meter run of kerbing restored.

407.04.8 Construction of Kerbcuts

Measurement shall be by meter run of kerbcuts constructed.

407.04.9 Restoration of Concrete Tiles/Blocks

Measurement shall be by meter square of concrete tiles/blocks restored.

407.04.10 Adjustment of Gully Inlets, Kerb Inlets or Manholes to New Pavement Elevations

Measurement shall be by number of gully inlets, kerb inlets or manholes adjusted (each measured separately).

407.04.11 Removal of Driveway Approaches

There shall be no measurement or payment for this work item which shall be considered as a subsidiary obligation to paid items under this Section of the Specifications.

407.04.12 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
407.1	Repair of Potholes	nr
407.2	Repair of Failed Pavement	sq.m
407.3	Repair of Depressed Pavement	sq.m
407.4	Repair of Utility Cuts (Case I Work)	sq.m
407.5	Repair of Utility Cuts (Case II Work)	sq.m
407.6	Restoration of Kerbing	m
407.7	Construction of Kerb Cuts	m
407.8	Restoration of Concrete Tiles/Blocks	sq.m
407.9	Adjustment of Gully Inlets to New Pavement Elevations	nr
407.10	Adjustment of Kerb Inlets to New Pavement Elevations	nr
407.11	Adjustment of Manholes to New Pavement Elevations	nr

408 - SEAL COATS (For Cement Modified Aggregates see Clause 411)

408.01 DESCRIPTION

This work shall consist of an application or applications of bituminous material and a cover aggregate or an application of bituminous material without aggregate, applied as specified herein for the respective Types of Seal Coats.

The type of Seal Coat to be applied as well as the type of bituminous binder to be used will be designated on the Drawings or specified in the special provisions except that Fog Seal shall consist of Emulsified Asphalt CSS-1h or SS-1h.

The various types of Seal Coat are shown in Table 408.01 together with the approximate application rates for aggregate and binder. The exact rates will be as stated in the bill of quantities and as determined by the Engineer.

Approximate Rate of Application		
Types of Seal Coats	**Aggregate (kg/m^2)**	*** Binder (kg/m^2)**
Fog Seal	-	0.24 - 0.48
Fine Aggregate Seal Coat	6.5 - 8.5	0.68 - 1.13
Medium-Fine Aggregate Seal Coat	8.5 - 10.5	0.68 - 1.13
Medium Aggregate Seal Coat	10.0 - 15.0	0.90 - 1.80
Coarse Aggregate Seal Coat	12.5 - 20.0	1.00 - 1.80
Double Aggregate Seal Coat		
1st Application (Coarse)	12.5 - 15.0	0.68 - 1.13
2nd Application (Fine)	6.5 - 8.5	0.68 - 0.90

*Application rates based on undiluted liquid or emulsified asphalts

Table 408.01 – Types of Seal Coats

408.02 MATERIALS REQUIREMENTS FOR SEAL COATS

408.02.1 General

All materials for Seal Coats shall comply with the requirements of Clause 402 of these Specifications except where modified herein.

408.02.2 Bituminous Materials

The bituminous material shall be of the type specified in the Contract Documents and shall comply with the requirements of Clause 402.06 (Liquid or Emulsified Asphalts) of these Specifications.

Anti-stripping agents are not required for cationic emulsions but shall be added to all other binder systems.

Where MC-70 liquid asphalt is specified the application temperature shall be between 60°C to 85°C (140°F to 185°F).

Emulsions should provide and retain a good coating on the aggregate proposed for use when subjected to the field coating test described in ASTM D244. Emulsions should be Cationic CRS-2 and shall be applied at the temperature between 50°C and 85°C (122°F and 185°F). Other binder systems can be used subject to the approval by the Engineer of the material and method of application.

408.02.3 Aggregate for Seal Coats

Fine and coarse aggregate for Seal Coat shall consist of crushed aggregate complying with the requirements of Clauses 402.01 and 402.02 of these Specifications.

The gradation of the aggregate shall be as shown in Table 408.02.3 for the various types of Seal Coats specified.

The aggregate shall be clean and free from dust, dust slurry and any other foreign matter prior to use. To obtain this the aggregate may have to be washed. In such cases, where an emulsion is used as a binder, the aggregate shall be drained thoroughly and be free of all surface water before application.

Sieve Sizes	TYPE OF SEAL AGGREGATE			
	Percent Passing %			
	Coarse	Medium	Medium-Fine	Fine
3/4 inch	100	-	-	-
1/2 inch	70-90	100	-	-
3/8 inch	0-15	99-100	100	100
1/4 inch	-	45-70	70-90	90 -100
No. 4	0-2	5-30	30-60	60 -85
No. 8	-	0-10	0-15	0-25
No. 16	-	0-5	0-5	0-5
No. 30	-	-	0-3	0-3
No. 200	-	0-2	0-2	0-2

Table 408.02.3 - Aggregate Gradations for Seal Coats

408.03 CONSTRUCTION REQUIREMENTS FOR SEAL COATS

408.03.1 Weather Limitations

Seal coats shall not be placed when the ambient temperature is less than 15^{o}C (60^{o}F) nor during rain, fog, dust-storms or other unsuitable weather.

408.03.2 Equipment Required

The equipment used by the Contractor shall include but not be limited to the following:

a. A self-powered bituminous material distributor in accordance with Clause 403.06 of these Specifications.

b. A self-propelled rotary power broom. Power brooms shall be self-propelled and equipped with a cylindrical, rotating nylon bristle brush of not less than 760 mm in diameter and not less than 1800 mm in length. The brush shall be capable of being angled to the right and left with adjustable ground pressure.

c. A self-propelled aggregate spreader of approved design supported by at least 4 wheels equipped with pneumatic tyres on two axles. The spreader shall be equipped with positive controls so that the required amount of material will be deposited uniformly over the full width of bituminous material. (Not required for Fog Seal). Minimum width of spreader box shall be 3.7 meters.

d. A minimum of one steel wheeled and one pneumatic tyred roller meeting the requirements of Clause 408.03.6 of these Specifications shall be provided. (Not required for Fog Seal).

e. A water truck equipped with a pressurized spray bar capable of applying a uniform fog spray as directed by the Engineer.

f. Air compressors, hand tools, etc. as required for preparation of the surface.

408.03.3 Construction of trial sections

Before commencement of Site seal coat applications, the Contractor shall construct trial sections using varying application rates for bitumen and for aggregates, as selected by the Engineer. Each trial section shall be 2 lanes wide by 50 m long, at approved locations on or close to the Site.

Each trial section shall be constructed using the same materials, mixing, spraying, spreading, rolling and brooming equipment, and construction procedures, proposed for use in the Works.

The objectives of these trials shall be to determine the adequacy of the Contractor's equipment, the fulfillment of the specified application rates for cutback bitumen, emulsified bitumen and the various gradations of aggregate, and the most suitable consistency of seal.

The Contractor shall not proceed with any seal coat applications until the methods and procedures established in the trials have been approved.

408.03.4 Surface Preparation

Where seal coats are to be applied to existing pavement surfaces, any pavement repairs shown on the Drawings or directed by the Engineer shall be completed in accordance with Clause 407 of these Specifications. Immediately before applying any bituminous material, all dirt, dust or other objectionable material shall be removed from the surface and cracks shall be sealed in accordance with Clause 407.03.5 of these Specifications as required. When so ordered by the Engineer, the surface shall be slightly dampened with a light application of water just prior to the application of bituminous material.

Where seal coats are to be applied directly to the subgrade or aggregate sub-base, the surface preparation shall be in accordance with Clause 405.03.5 of these Specifications.

408.03.5 Applying Bituminous Material

Bituminous material shall be applied by means of the pressure distributor in a uniform, continuous spread over the section to be treated and within the temperature range specified. The rate of application of bituminous material shall be as directed by the Engineer. A strip of heavy paper, approximately 1 meter in width extending beyond the width of spray from the distributor shall be used at the beginning of each spread. If the cut off is not positive, the use of paper may be required at the end of each spread. The paper shall be removed and disposed off by the Contractor. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected immediately as directed.

The length of spread of bituminous material shall not be in excess of that which can be immediately covered with aggregate. The spread of bituminous material shall not be more than 150 mm. wider than the width covered by the aggregate from the spreading equipment. Under no circumstances shall operations proceed in such manner that bituminous material will be allowed to set up, dry or otherwise impair retention of the cover aggregate.

The surfaces of structures and appurtenances adjacent to areas being treated shall be protected in such a manner as to prevent spattering or marring. No bituminous material shall be discharged into gullies.

For Double Aggregate Seal Coats the second application of bituminous material shall be applied with the distributor operated in the opposite direction from the first application.

The Contractor shall keep a complete record of bitumen used, based on distributor tank measurements and on areas to which the bitumen has been applied. These records shall be submitted to the Engineer as verification of the accuracy of the tachometer as well as verification of application rates designated by the Engineer.

Distribution of bitumen shall be so regulated and sufficient material left in the distributor at the end of each application, that there will be a uniform distribution across the spray bar. In no case shall the distributor be allowed to expel air with the bitumen, thereby causing uneven coverage.

The angle of the spray nozzles and the height of the spray bar shall be adjusted and regularly checked to ensure uniform distribution. The height of the spray bar above the pavement surface should remain constant throughout the spraying process. Distribution shall cease immediately upon any clogging or partial blocking of any nozzle and corrective measures shall be taken before application is resumed.

408.03.6 Applying Aggregate

Immediately following the application of the bituminous material, the specified aggregate shall be spread at the rate designated by the Engineer. Spreading shall be accomplished in such a manner that the tyres of the hauling units or aggregate spreader at no time contact the uncovered and newly applied bituminous material. Junctions

of spreads shall be carefully made to assure a smooth riding surface.

The aggregates shall be pre-moistened and mixed with water 24 hours prior to use to eliminate or reduce the dust coating so that they are uniformly damp at the time of use. The Engineer may also require that the aggregates be redampened in the hauling units just prior to delivery to the spreader.

Where adjacent spreads are to be made, the first aggregate spread shall not extend closer than 150 mm to the edge of bitumen application. The adjacent spread of bitumen shall overlap this 150 mm and complete aggregate coverage shall be achieved on the second spread promptly upon completion of the first spread to ensure a smooth riding surface

Operating the aggregate spreader at speeds which cause the particles to roll over after striking the bituminous covered surface will not be permitted.

Immediately after the aggregate is spread, any deficient areas shall be covered by additional material. Any piles, ridges or uneven distribution of aggregate shall be carefully removed and corrected to ensure against permanent ridges, bumps or depressions in the completed surface. Additional aggregate shall be spread in whatever quantities necessary to prevent picking up by the rollers or traffic, after which the surface shall be rolled.

Care shall be taken to prevent aggregate from entering gullies and the Contractor will be responsible for cleaning the gullies of any debris caused by his operation.

Initial rolling shall consist of one complete coverage performed with the steel-wheeled roller (5000 to 10000 kg weight) and shall begin immediately behind the spreader. Crushing of aggregates by excessive rolling shall be avoided. Binder and aggregate shall not be spread more than 200 meters ahead of completion of the initial rolling operations. Pneumatic tyred rolling shall begin immediately after completion of the initial rolling and shall be continued until the aggregate is firmly embedded in the binder and in no case shall be less than two complete coverages.

Steel wheeled rollers shall be operated at a maximum speed 5 km/h. Pneumatic-tyred rollers shall be operated at a maximum speed of 8 km/h.

Should the Engineer deem it necessary, supplemental spreading and smoothing by broom drag or hand methods may be required prior to rolling.

408.03.7 Maintenance of the Surface

A. Fog Seal

The Fog Seal shall be protected from traffic for a minimum of two hours after placement. Where required by the Engineer, water shall be sprayed on the surface to reduce tackiness prior to opening the Fog Seal to traffic.

B. All other Seal Coats

The completed surface shall be lightly broomed and otherwise maintained as directed by the Engineer for a minimum period of 5 days. Maintenance of the surface shall include the distribution of additional aggregate over the surface to absorb any free bituminous material and cover any area deficient in aggregate. The maintenance shall be conducted so as not to displace imbedded material. Excess material shall be swept from the entire surface by means of rotary brooms. The surface shall be swept at the time determined by the Engineer. Where double aggregate seal coat is specified the second application shall be made no sooner than 5 days after the first application.

408.03.8 Traffic Control

The Contractor shall at all times provide and maintain satisfactory signs, barricades, barrels, flagmen, warning lights, etc. so as to protect the surface from all types of traffic throughout the maintenance period and as directed by the Engineer. Any damage to the Seal Coat shall be satisfactorily repaired by the Contractor at his own expense.

408.04 CHIP SEAL COAT

408.04.1 General

A chip seal coat shall be applied to all shoulder areas as shown on the Drawings, as specified herein, and as directed by the Engineer. The shoulder chip seal is to provide a colour and riding surface contrast between the travelled way and shoulders, utilizing a light coloured aggregate, as approved by the Engineer, and in all other respects shall meet the requirements of this Clause 408 of these Specifications.

The Chip Seal Coat shall be a single coat application unless otherwise specified.

408.05 METHOD OF MEASUREMENT AND PAYMENT

408.05.1 Measurement of Seal Coats

The quantity of seal coat to be paid for shall be the net number of the square meters acceptably placed in accordance with the Drawings or as directed by the Engineer.

408.05.2 Payment for Seal Coats

Payment for the Seal Coat shall be at the rate shown in the Bills of Quantities for the respective Types of Seal Coat specified. The rate shall include full compensation for furnishing all material, labour, tools, equipment and incidentals and for performing all the work involved in placing the seal coat complete in place including cleaning the surface, sealing cracks, protecting the surface until it has cured as well as the necessary traffic control.

408.05.3 Measurement and Payment for Chip Seal Coats

Measurement and payment for shoulder chip seal shall be as specified for seal coats in Clauses 408.05.1 and 408.05.2 of these Specifications, and at the rate as included in the Bills of Quantities for each specific type of Chip Seal Coat.

408.05.4 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
408.1	Fog Seal	sq.m
408.2	Fine Aggregate Seal Coat	sq.m
408.3	Medium Fine Aggregate Seal Coat	sq.m
408.4	Coarse Aggregate Seal Coat	sq.m
408.5	Double Aggregate Seal Coat	sq.m
408.6	Chip Seal Coat (Type)	sq.m

409 - PLANT MIX SEAL
(For Cement Modified Aggregates see Clause 411)

409.01 DESCRIPTION

This work shall consist of hot asphalt plant mix seal coat composed of a mixture of bituminous material including antistrip, crushed aggregates, hydrated lime and mineral filler mixed in a central plant. The mixture shall be machine laid on a prepared paved surface in accordance with the Specifications and in conformity with the thickness and dimensions specified or as directed by the Engineer. The requirements of Section 4 of these Specifications shall apply to this work except where modified herein.

409.02 DESIGN REQUIREMENTS FOR PLANT MIX SEAL

409.02.1 Materials for Plant Mix Seal

Each individual stockpile of crushed coarse aggregate shall have a flakiness index as described in Clause 402.02 of these Specifications of not more than 25%.

The percentage of soft and friable particles (mesh) for coarse aggregate as determined by MPW procedures

shall not exceed 2% by weight.

Hydrated lime meeting the requirements of Clause 402.07 of these Specifications may be added to the aggregates in accordance with Clause 403.02.2c of these Specifications in an amount not less than 1.5% by weight of aggregates.

A certain proportion of crushed sand may be added to Plant Mix Seal to enhance the properties and satisfy the job mix formula.

Anti-stripping additives shall be added to all plant mix seal.

409.02.2 Composition of Plant Mix Seal

The composition of plant mix seal including commercial filler and hydrated lime, if used, shall meet the requirements shown in Table 409.02.2.

GRADATION LIMITS

Sieve Size	Percent passing by weight	Maximum Allowable Tolerances from the Job Mix Formula
1/2 inch	100	0
3/8 inch	95 - 100	± 5
No. 4	30 - 50	± 7
No. 8	5 - 15	± 3
No. 200	3 – 6 Gradation may include hydrated lime	± 2
Asphalt Cement (% by weight of aggregate)	5.5 to 7.5	± 0.4
Antistripping Additive (% by weight of bitumen)	1.5 Maximum	-

Table 409.02.2 - Composition of Plant Mix Seal

409.02.3 Job Mix Formula

The Job Mix Formula as submitted by the Contractor and as approved by the Engineer shall be within the gradation limits specified and will provide for the maximum percent passing the No. 8 sieve which will not reduce the voids in the mix to less than 15%. The retained strength when tested in accordance with AASHTO T 165 (except that a moulding pressure of 140 kg/cm2 (2000 psi) shall be used) shall not be less than 50%. The required bitumen content will be as determined by the Engineer.

Asphalt mixes with any variation beyond the allowable tolerance specified in Table 409.02.2 delivered and used in the work may, at the discretion of the Engineer, be rejected, removed and replaced. The lack of a satisfactory quantity of hydrated lime will be considered a major defect in the work.

409.03 CONSTRUCTION REQUIREMENTS FOR PLANT MIX SEAL

409.03.1 General

Construction requirements for Plant Mix Seal shall be the same as those used for Asphaltic Concrete, Clause 404 of these Specifications, subject to the following modifications:

409.03.2 Weather Limitations

When applied for Plant Mix Seal, Clause 404.03.1 of these Specifications shall be modified as follows: Plant Mix Seal shall not be placed when the ambient shade air temperature is less than 15°C (60°F), nor during rain, fog, dust storms or other unsuitable weather.

409.03.3 Survey and Preparation of Area to be Paved

In addition to the requirements of Clause 404.03.3 of these Specifications, all Pavement Repair items shown on the Drawings or directed by the Engineer shall be completed in accordance with Clause 407 of these Specifications prior to placing the Plant Mix Seal.

409.03.4 Mixing and Placing

Asphalt, Aggregate and Mix temperatures shall be so modified that the temperature at which plant mix seal aggregates and bitumen are mixed shall be between 116°C and 123°C (240°F and 250°F) and the temperature of the mix at the time of placement shall be between 110°C and 123°C (230°F and 250°F).

Plant mix seal material is to be placed within one hour of manufacture. Plants are to be equipped with a time stamp machine and each delivery truck is to be provided with a delivery ticket showing the time of loading.

409.03.5 Spreading and Finishing Equipment

Automatic spread control actuated by a 9 meter ski-type averaging arm shall be used when placing Plant Mix Seal. Plant Mix Seal shall not be placed unless the underlying layer strictly conforms to the surface tolerances requirements of Clause 404.03.10 of these Specifications unless otherwise approved by the Engineer.

The restriction of Clause 404.03.7 of these Specifications with respect to the number of paving machines in operation for the stated batching plant outputs shall not apply for the laying of plant mix seal. The number of paving machines which the Contractor proposes to use shall be approved by the Engineer prior to commencing laying operations.

409.03.6 Spreading of Plant Mix Seal

Clause 404.03.7 of these Specifications shall be modified so that Plant Mix Seal Coat shall be placed in a single layer to obtain a compacted thickness of 20 mm with a tolerance of ±5 mm.

409.03.7 Compaction of Plant Mix Seal

Clause 404.03.8 of these Specifications shall be modified as follows: Compaction shall be accomplished by an 8000 to 12000 kg steel-wheeled roller providing a minimum of two complete coverage passes. Pneumatic-tyred rollers shall not be used for initial compaction. Later rolling with pneumatic-tyred rollers may be requested by the Engineer at no additional cost.

409.03.8 Testing and Acceptance of Completed Plant Mix Seal

A. <u>Requirements for Aggregate, Asphalt Content, Gradation and Hydrated Lime</u>

Coarse aggregate used in the plant mix seal shall have a loss of not more than 25% when tested in accordance with AASHTO T 96 and a maximum loss of 10% at 5 cycles when subjected to the sodium sulphate soundness test using AASHTO T 104, A minimum of 80% by weight of the coarse aggregate shall be crushed pieces having one or more faces produced by fracture.

The coarse aggregate shall be heterogeneous and non-carbonate.

Samples of plant mix seal shall normally be taken at the place of manufacture in accordance with AASHTO T168.

Should it transpire from the analysis conducted on samples of Plant Mix Seal that the asphalt content or aggregate gradation are beyond the permissible tolerances specified for the Job Mix Formula established or that a satisfactory quantity of hydrated lime, if used, is not present, and that, as determined by the Engineer, such variation affects the characteristics of the asphalt mix as far as its conformity to the Contract Conditions and Specification is concerned, this shall be considered a major defect in the work on the basis of which the portion of the Plant Mix Seal represented by these samples shall be rejected.

B. <u>Requirements for Evenness of Surface</u>

When tested by a 4 meter straight edge placed at right angles and parallel to the road centreline at intervals not exceeding 2 meters, variation of the surface of the plant mix seal from the straight edge shall not exceed 4 mm.

409.04 MEASUREMENT AND PAYMENT

409.04.1 Method of Measurement and Basis of Payment for Plant Mix Seal

Measurement of Plant Mix Seal shall be by meter square in accordance with the Drawings, Specifications or as

directed by the Engineer. No deduction shall be made for the area of any rumble strips.

Payment for Plant Mix Seal shall be at the rate shown in the Bills of Quantities.

409.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
409.1	Plant Mix Seal	sq.m

410 - SLURRY SEAL
(For Cement Modified Aggregates see Clause 411)

410.01 DESCRIPTION

This work shall consist of mixing asphaltic emulsion, aggregate, mineral filler and water into a stable slurry mixture and spreading the mixture on a prepared surface or pavement as shown on the Drawings and as directed by the Engineer. The requirements of Section 4 of these Specifications shall apply to this work except where modified herein.

410.02 DESIGN REQUIREMENTS FOR SLURRY SEAL

410.02.1 Materials

A. Emulsified Asphalt

Emulsified asphalt shall meet the requirements of Clause 402.06 of these Specifications. In general, Cationic Emulsion CSS-1h shall be used, unless the Contractor is directed in writing by the Engineer to use Anionic Emulsion SS-1h. The percent of residual bitumen by weight of dry aggregate will generally range between 7.0% to 13.5%.

B. Water

All water used in making the slurry shall be potable and free of dissolved ingredients that may prove harmful.

C. Commercial Mineral Filler

Commercial mineral filler used in Slurry Seal shall be Portland Cement or Hydrated Lime in accordance with Clause 402.03 or 402.07 of these Specifications as directed by the Engineer. 3% filler by weight will normally be used provided such use does not interfere with the total aggregate gradation nor with the properties of the slurry. More filler or less filler may be required, subject to the mix design.

D. Aggregate for Slurry Seal

The aggregate used for slurry seal shall be crushed and shall comply with Clauses 402.01 and 402.02 of these Specifications except that the Sand Equivalent of any individual stockpile shall be greater than 45. The crushed aggregate shall be cubic and angular in shape; i.e. flaky or thin elongated particles will not be permitted. The gradation of the crushed aggregate (without commercial mineral filler) shall be as shown in Table 410.02.1:

Sieve	Percent Passing
3/8 inch	100
No. 4	98 - 100
No. 8	65 - 90
No. 16	45 - 70
No. 30	30 - 50
No. 50	18 - 30
No. 100	10 - 21
No. 200	5 - 15

Table 410.02.1 – Crushed Aggregate Gradation for Slurry Seal

The weight of dry aggregate, including filler will generally be applied at a rate of between 5.4 and 8.6 kg/m2.

410.02.2 Job Mix Design

The Engineer shall test samples of the materials proposed for use by the Contractor to check them for conformance with these Specifications and to evaluate them as to their suitability for use in a slurry. The Engineer will instruct whether the proposed materials are acceptable. The Contractor shall propose for the Engineer's approval the type and amount of emulsion required, the type and amount of commercial mineral filler required and the range of pre-wet mixing water to be added.

Approval by the Engineer shall in no way relieve the Contractor of his responsibilities and obligations under the Contract.

410.02.3 Composition of the Slurry

The amount of asphaltic emulsion to be blended with the aggregate will be approved by the Engineer, subject to final adjustment in the field to allow for absorption by the existing surface. The amount of water added must be controlled accurately to ensure production of a readily spreadable yet completely stable slurry. The proper water content shall be determined by an appropriate consistency test on freshly made slurry.

Slurry Stability may be checked at any time during the work by drawing a solid object (such as a stick) through the sample of the mixture concerned. If the resulting surface depression persists more or less indefinitely, the slurry is stable. If, however, such a depression fills quickly with the liquids present, leaving an essentially smooth horizontal surface, the mixture tested is not a slurry and should not be applied.

The slurry shall be a homogeneous mixture, sufficiently stable during the entire mixing-spreading period so that the emulsion does not break and so there is no segregation of the fines from the coarser aggregate and the liquid portion of the mix does not float to the surface. Total time of mixing, from introduction of emulsion to spreading, shall be 2 minutes or less. The Engineer shall give final approval of the mixture proportions and of the thickness of application.

410.03 CONSTRUCTION REQUIREMENTS

410.03.1 Weather Limitations

Slurry Seal shall not be placed when the ambient temperature is below 15^{o}C (59^{o}F) nor during rain, fog, dust-storms or other unsuitable weather. Should the pavement surface temperatures be such as to adversely affect the setting and curing of the slurry, the Engineer may suspend work or otherwise limit it to certain hours of the day.

410.03.2 Equipment Required

A. <u>Slurry Mixing Equipment</u>

The slurry mixing machine shall be a self-propelled continuous flow mixing unit, as approved by the Engineer, capable of delivering accurately predetermined proportions of aggregate, filler, water and asphalt emulsion to a mixing apparatus and of discharging the thoroughly mixed product on a continuous basis. The aggregate shall be pre-wetted immediately prior to mixing with the emulsion. The mixing apparatus shall be capable of thoroughly blending all ingredients together without violent action. The mixing machine shall be equipped with an approved fines feeder that provides an accurate metering device or method of introducing a predetermined proportion of mineral filler into the mixer as the aggregate is fed in. The mixing machine shall be equipped with a water pressure system and fog type spray bar adequate for completely fogging the surface with up to 0.4 liters per square meter immediately ahead of the spreading equipment. The machine shall be capable of mixing materials at pre-set proportions regardless of speed of machine and without changing machine settings.

B. <u>Slurry Spreading Equipment</u>

Attached to the mixing machine shall be a mechanical type squeegee distributor, having a rubber-like material in contact with the surface to prevent unwanted egress of slurry. It shall prevent loss of slurry on varying grades and crown by adjustments to assure uniform spread. An appropriate mechanical device for lateral distribution of the slurry shall be operated within the spreader box. There shall be a steering device and a flexible strike off. The spreader box shall be adjustable to various widths from 2.4 meters upward. The box shall be kept clean, no extensive build-up of asphalt and aggregate on the box being permitted. Hessian or burlap drags may be

required by the Engineer to provide the desired surface texture.

C. Cleaning Equipment

Power-brooms, power-blowers, air compressors, water flushing equipment, and hand brooms suitable for cleaning the pavement surface and cracks therein. Power brooms shall be self-propelled and equipped with a cylindrical, rotating nylon bristle brush of not less than 760 mm in diameter and not less than 1800 in length. The brush shall be capable of being angled to the right and left with adjustable ground pressure.

D. Auxiliary Equipment

Hand squeegees, shovels and other equipment necessary to perform the work.

410.03.3 Equipment Calibration

The Contractor shall provide the Engineer with the manufacturer's information regarding the operation, calibration and maintenance of the mixing and spreading equipment at least 30 days prior to starting the work. Slurry machines produced by different manufacturers will have different methods of calibration. However, a calibration method based on a revolution counter will be applicable to all machines. By attaching a revolution counter to any shaft that is mechanically interlocked with the emulsion pump, water pump, fines feeder and the aggregate conveyor, the relative quantities of each of these components per revolution can be determined for various gate openings, meter valve openings, or sprocket sizes.

Prior to the start of work and at any other time as directed by the Engineer, the equipment shall be calibrated with the materials approved for use in the work. The Contractor shall provide satisfactory scales, pans, containers and other equipment and labour necessary to perform the calibrations as directed by the Engineer.

410.03.4 Surface Preparation

Prior to placing the slurry, any Pavement Repairs according to Clause 407 of these Specifications as required by the Drawings or as directed by the Engineer shall be completed. Cracks shall be cleaned and filled as required in Clause 407.03.5 of these Specifications.

The surface shall be cleaned of all dirt and other loose and objectionable materials just prior to the application of the slurry. Any standard cleaning method will be acceptable, except that water flushing will not be permitted in areas where considerable cracks are present in the pavement surface.

410.03.5 Application of the Slurry Seal

A. General

The surface shall be fogged with water directly preceding the spreader at the rate determined by the Engineer. The slurry mixture shall be of the desired consistency as it leaves the mixer and no additional elements shall be added. A sufficient amount of slurry shall be carried in all parts of the spreader at all times so that complete coverage is obtained. No lumping, balling or unmixed aggregate or filler shall be permitted. No segregation of the emulsion and aggregate fines from the coarse aggregate will be permitted. If the coarse aggregate settles to the bottom of the mix, the slurry will be removed from the pavement. No excessive breaking of the emulsion shall be allowed in the spreader box. No streaks such as caused by oversized aggregate shall be left in the finished pavement.

B. Joints

No excessive build-up nor unsightly appearance shall be permitted on longitudinal or transverse joints. When hessian or burlap drags are used, they must be kept relatively clean and free of excessive build-up.

C. Handwork

Approved squeegees shall be used to spread slurry in areas not accessible to the slurry spreader box. Care shall be exercised in leaving no unsightly appearance from handwork.

D. Curing

Treated areas will be allowed to cure until such time as the Engineer allows opening to traffic. Where required

by the Engineer, rolling of the slurry while the mix is still tender shall be accomplished using a minimum of 5 coverage passes with a 5000kg roller. Where a pneumatic roller is used the maximum tyre inflation pressure shall be 3.5 kg/m2 (50 psi).

410.03.6 Traffic Control

The Contractor shall at all times provide and maintain satisfactory signs barricades, barrels, flagmen, warning lights, etc. so as to protect the slurry surface from all types of traffic for a minimum of 24 hours after placement or as directed by the Engineer. Any damage to the uncured slurry will be the responsibility of the Contractor.

410.04 MEASUREMENT AND PAYMENT

410.04.1 Method of Measurement and Basis of Payment for Slurry Seal

The quantity of slurry seal to be paid for shall be the net number of the square meters acceptably placed in accordance with the Drawings or as directed by the Engineer.

Payment for Slurry Seal shall be at the rate as shown in the Bills of Quantities which rate shall include full compensation for all material, equipment and labour required to perform the work involved in constructing the slurry seal in accordance with these Specifications and shall include cleaning the surface, sealing cracks, protecting the surface until it has cured, as well as the necessary traffic control.

410.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
410.1	Slurry Seal	sq.m

411 - CEMENT MODIFIED ASPHALT COURSES

411.01 DESCRIPTION

This work consists of constructing a cement modified asphalt pavement course on a prepared surface in accordance with these Specifications and in conformity with the lines, grades, thicknesses and typical cross-sections shown on the Drawings or directed by the Engineer. The requirements of Clause 304 of Section 3 (Sand Asphalt Sub-base and Base Courses), Clauses 401 to 403 inclusive (Asphalt Works), Clause 404 (Asphaltic Concrete), Clause 409 (Plant Mix Seal), Clause 410 (Slurry Seal) of these Specifications shall apply to this work except as modified in this Clause 411.

The layers comprising the Asphalt Pavement Section shall have the following designations, unless otherwise shown on the Drawings or directed by the Engineer.

Asphalt Paving Course	Mix Type
Sand Asphalt Sub-Base course Containing Cement Coated Aggregate	A
Asphaltic Concrete Base Course Containing Cement Coated Aggregate	I
Asphaltic Concrete Binder Course Containing Cement Coated Aggregate	II
Asphaltic Concrete Wearing Course Containing Cement Coated Aggregate	III
Plant Mix Seal Containing Cement Coated Aggregate	-

Mix types, materials, testing and method of construction of the above courses shall conform with the requirements for Asphalt Mixes as set out in these Specifications except what is particularly specified hereafter for preparation, placing and testing of asphalt mixtures and layers containing cement coated aggregate.

411.02 DESIGN REQUIREMENTS FOR CEMENT MODIFIED ASPHALT COURSES

411.02.1 Materials

a. All coarse and fine aggregates shall conform to the physical and mechanical properties as specified in these Specifications.

b. Portland Cement Type I shall be used for coating aggregates.

c. Potable water as specified in Clause 501.05 of Section 5 (Concrete Works) of these Specifications shall be used in the cement coating of aggregates and for curing cement coated aggregates.

411.02.2 Design Criteria, Job Mix Formula and Allowable Tolerances

The Design Criteria, Job Mix Formula and Allowable Tolerances for all asphaltic mixtures containing cement coated aggregates shall conform to the requirements set out in Clauses 404.02.3 and 404.02.4 of these Specifications except for the special provisions described in Table 411.02.2 and herein:

Mix Type	75 blows Minimum Marshall Stability
Sand Asphalt (Cement Coated Aggregate)	550 kg
Asphaltic Concrete Type I (Cement Coated Aggregate)	1600 kg
Asphaltic Concrete Type II (Cement Coated Aggregate)	1700 kg
Asphaltic Concrete Type III (Cement Coated Aggregate)	1800 kg

Table 411.02.2: Cement Modified Asphalt Courses Stability Requirements

For all mix types, the Index of Retained Strength as determined by AASHTO T165-77 (ASTM D1075-75) shall have a minimum value of 90%.

Mixes having indices of retained strength of less than 90% may be considered acceptable by the Engineer provided the net retained strength for plant mix seal exceeds 8 kg/cm2, sand-asphalt 9.5 kg/cm2 and other asphaltic mixes 14 kg/cm2.

411.03 CONSTRUCTION REQUIREMENTS FOR CEMENT MODIFIED ASPHALT COURSES

411.03.1 Equipment for Cement Coating of Aggregates

a. Equipment for mixing the cement coated aggregate may be central-mix batch, transit, continuous flow revolving drum or continuous flow pugmill. Mixing equipment and procedures shall be subject to approval by the Engineer on the basis of uniformity of coating. The output of the cement coating facility shall be such that the production schedule of the asphalt plant is always maintained.

b. Storage arrangements for pre-treated aggregate at the cement coating facility shall be such as to ensure separate storage of the various aggregate fractions and shall be of sufficient capacity to supply the cement coating equipment when it is operating at full output.

c. The means of accurately weighing aggregate fractions shall conform to the requirements as set out in these Specifications. Scales, meters and feeders shall be checked and calibrated as directed by the Engineer. The plant shall be equipped to add water both in the mixer and at the beginning of the conveyor belt feeding the coarse aggregate to the mixer.

d. Means of accurately supplying the mixes with the required amount of water shall be provided.

e. Provision shall be made in the cement coating plant for transportation of coated aggregates to curing bins.

411.03.2 Cement Coating of Aggregates

a. Each size of coarse aggregate, the natural sand and the crushed sand shall be coated separately. Mineral

filler shall not be coated.

b. Aggregate, Portland cement and water proportions for cement coating of aggregates shall be as given in Table 411.03.2:

Aggregate Size and Type	Cement % by weight of dry aggregate	Water for Hydration % by weight cement	Water for Absorption % by weight of dry aggregate
1-1/2 inch	1.3 - 1.7	23	0.9
1 inch	1.7 - 2.0	23	0.9
3/4 inch	2.0 - 2.5	23	0.9
1/2 inch	3.0 - 4.0	23	0.9
3/8 inch	4.0 - 4.5	23	0.9
Crushed Sand	6.5 - 7.0	23	1.2
Natural Sand	6.0 - 6.5	23	1.2

Table 411.03.2: Cement and Water Requirements for Cement Coating of Aggregates

The quantity of water required for cement coating of aggregates shall be the quantity for hydration plus the quantity for absorption and evaporation losses. The actual quantity of water proportioned shall be approved by the Engineer from the results of aggregate moisture tests and quality of coating considerations. If the moisture content of the aggregate exceeds the requirements for coatings, the moisture content shall be reduced by aeration. The moisture content of the aggregate shall be determined at intervals designated by the Engineer and the quantity of water required for cement coating adjusted accordingly.

c. The sequence of charging materials into the mixer and the mixing time shall be adjusted as necessary to produce uniform coating of the particles, except all or part of the water shall be added to the coarse aggregates at the beginning or the conveyor belt feeding them to the mixer.

d. The freshly coated aggregates shall be moved directly from the mixer to the curing area and not be rehandled until after a minimum curing of 48 hours. Either an impermeable cover placed directly on the surface of the stockpile or a water sprinkling system shall be used for curing.

e. Cement coated aggregates will be accepted in the stockpile after curing. At the Engineer's option the cement content of the coated aggregates may be determined for acceptance by AASHTO T211. Acceptance will also be based on the uniformity of coating, the percentage of particles satisfactorily coated, the acceptability of the curing procedure and other factors determined by the Engineer.

The Engineer's decision on the acceptability of the cement-coated aggregate will be final.

f. Following the curing period the cement coated aggregates shall be treated in the same way as conventional aggregates and all subsequent operations shall be in accordance with these Specifications.

411.03.3 Compaction Requirements for Asphaltic Concrete Courses Containing Cement Coated Aggregates

The degree of compaction required for the various Asphaltic Concrete Types shall conform to the requirements set out in these Specifications. The mix temperature prior to breakdown rolling shall be a minimum of 120^0C for the cement coated aggregates.

411.03.4 Strength Specifications for Asphaltic Concrete Pavement Courses Containing Cement Coated Aggregates

The cement modified asphaltic concrete and sand mix pavement courses shall be compacted and tested for acceptance in accordance with the compaction requirements in these Specifications.

In addition, each layer of permanent asphaltic concrete pavement placed and compacted including asphaltic concrete pavement for Type IV – long terms detours shall be tested for the degree and uniformity of stiffness by measuring the in-situ deflections. The test method will be a measurement of dynamic deflection using Dynaflect

equipment.

The results of Dynaflect testing shall be considered a measure of conformance to specification requirements for the asphaltic concrete pavement.

Table 411.03.3 is to be used as a guide and the actual limiting deflection which will fall within the range given in Table 411.03.3 will be calculated at the time of testing.

The range of deflection limits for Dynaflect testing shall be as shown in Table 411.03.3

Asphalt Thickness mm	Range of W1 Deflection Limit milli inches
60	1.10
80	1.08
100	1.02 - 1.08
120	0.94 - 1.08
150	0.84 - 1.04
180	0.74 - 1.02
200	0.70 - 1.00
230	0.62 - 0.98
260	0.58 - 0.96
280	0.54 - 0.94
300	0.52 - 0.92

Table 411.03.3 – Range of deflection limits for Dynaflect testing

Dynaflect testing shall be performed longitudinally across the full width of the asphaltic concrete pavement. Testing will be at maximum intervals of 25 meters and representing a maximum width of 4 meters.

A minimum of 5 tests shall be made out on every strip tested.

The Contractor shall be notified by the Engineer that the tested layer is accepted or rejected within 24 hours, excluding Fridays and Kuwait holidays, following the time the Dynaflect test was made by the Contractor under the Engineer's direction, and the results were handed over to the Engineer.

Where Dynaflect test results fail to meet minimum deflection requirements, the Contractor shall at his expense rework, recompact or if necessary remove and replace the work as required to produce satisfactory test results.

In the event that Dynaflect testing of a layer is not possible, the work may be accepted at the discretion of the Engineer on the basis of the material meeting all other Specification requirements. In such cases, however, the subsequent layer shall only be accepted on the basis of Dynaflect tests.

411.04 MEASUREMENT AND PAYMENT

411.04.1 Method of Measurement and Basis of Payment for Cement Modified Asphalt Courses

Measurement for the various cement modified asphalt courses shall be in accordance with requirements for the measurement of the corresponding courses in Section 3 (Subbase and Base Courses) and Clause 404 to Clause 410 inclusive of these Specifications.

Payment for various cement modified asphalt courses shall be at the rates shown in the Bills of Quantities which shall include full compensation for all material, plant and labour required to construct the cement modified asphalt courses to the requirements of these Specifications.

Where new road construction work adjoins or meets existing road construction, e.g. new shoulders and cross-roads, no separate payment will be made for cutting back the edges of the existing construction to receive the new surfacing layers, the cost being deemed to be included with the cost of the new surfacing courses.

411.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
411.1	Cement Modified Asphalt Course (Type, Thickness)	sq.m

412 - RUMBLE STRIPS

412.01 GENERAL REQUIREMENTS

Rumble strips shall be constructed as shown on the Drawings by cold milling of the completed pavement.

Rumble strips which are shown on the Drawings to be shorter in length than the cutting cylinder of the approved milling machine may be formed by using removable shutter boards rigidly located on the binder course prior to laying the plant mix seal. The strips formed by this method shall be rerolled with a pneumatic tyred roller to recompact the edges.

Equipment to be used and method of work shall be approved by the Engineer prior to construction and trial series of rumble strips shall be constructed to prove the proposed method of work. With the approval of the Engineer the trial series may be incorporated into the permanent works. Unsatisfactory trail rumble strips shall be patched to match surrounding pavement to the approval of the Engineer.

412.02 MEASUREMENT AND PAYMENT

412.02.1 Method of Measurement and Basis of Payment

Measurement for rumble strips shall be by the number formed by milling and by fixed boards.

Payment shall be at the rate inserted in the Bills of Quantities which rate shall include for all labour, plant and material to complete the rumble strips. The forming and patching of trial rumble strips not approved for inclusion in the Works shall not be paid for and shall be deemed to have been included in the rate inserted for rumble strips.

412.02.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
412.1	Rumble Strips	nr

413 - SHOULDER TREATMENT

413.01 SCOPE

This work consists of the application of a combination of coats of materials to provide a dense and uniform treatment to shoulder areas as shown on the Drawings and as directed by the Engineer. The shoulder aggregate seal shall provide a colour and riding surface contrast between the travelled way and the shoulder utilizing a light coloured aggregate as approved by the Engineer.

413.02 MATERIALS

Materials for the shoulder treatment shall comply with the following Clauses of these Specifications:

a	Tack Coat	Clause 406
b	Sand Asphalt	Clause 411
c	Emulsified Asphalt	Clause 408.02.2
d	Coarse Aggregate	Clause 408.02.3

413.03 APPLICATION OF MATERIALS

The materials shall be laid strictly in accordance with the following procedure:

a. Tack coat shall be applied to the Type II binder course in accordance with Clause 406 of these Specifications.

b. The sand asphalt shall then be laid in accordance with Clause 411 of these Specifications to achieve a finished thickness of 15mm.

c. Immediately following rolling of the sand asphalt, emulsified asphalt type CSS 1h shall be applied to the sand asphalt surface at the rate of 0.75 – 1.05 kg/m2 strictly in accordance with requirements of Clause 408.03 of these Specifications.

d. Coarse Aggregate shall then be applied to this surface at the rate of 6.5 – 8.5 kg/m2 in accordance with the requirements of Clause 408.03 of these Specifications.

The operating speed of the bituminous material distributor and the aggregate spreader shall be co-ordinated as directed by the Engineer and in no case shall the separation distance exceed 25m.

413.04 MEASUREMENT AND PAYMENT

413.04.1 Method of Measurement and Basis of Payment

Measurement of Shoulder Treatment shall be by the meter square in accordance with the Drawings, Specifications or as directed by the Engineer.

Payment will be made at the rate indicated in the Bills of Quantities, which rate shall be full compensation for the provision and application of the tack coat, sand asphalt, emulsified asphalt and coarse aggregate and for all equipment and labour necessary for the proper completion of the work.

413.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
413.1	Shoulder Treatment	sq.m

414 - RECYCLED ASPHALT PAVEMENT

414.01 DESCRIPTION

This work shall consist of producing and constructing Recycled Asphalt Concrete Pavement, composed of both new and reclaimed asphalt concrete materials combined in a uniform heated mixture by means of a central mixing plant and in conformity with the Job Mix Formula approved by the Engineer. As specified in the Contract Documents, the source of the reclaimed material shall be certain stockpiles of uncrushed asphaltic pavement material previously reclaimed or material reclaimed under this Contract from designated sections of existing roadway. Except salvaging work performed under Clause 207 of Section 2 (Earthworks) of these Specifications, this work shall include all necessary hauling, crushing, storing and processing of the reclaimed material; addition of new materials to the mixture; heating, mixing, hauling and placement of the recycled material; restoration of stockpile sites; and disposal of waste and unusable material.

The requirements of Clauses 401, 402, 403 and 404 of these Specifications shall apply to this work except as modified herein. Cement-coated aggregates are specified for recycled mixtures; Clause 411 of these Specifications shall apply in the preparation of the new aggregates.

414.02 MATERIALS

All new ingredients required shall be furnished by the Contractor; the reclaimed asphaltic concrete shall be furnished by the Government of Kuwait, which retains ownership of this material while it is in the possession or control of the Contractor. 65% ± 5% of the total aggregates by weight shall consist of new materials. 2.7% ± 0.5% by weight of the total aggregates shall consist of new asphalt cement. A mix design with a higher proportion of new materials may be required in the event that (1) an acceptable mix design cannot be obtained at the above percentages, (2) the mixture proves difficult to screed and compact, or (3) control of the mixture cannot be maintained within the tolerances specified in Clause 414.05 of these Specifications. Measurement and payment for extra materials shall be as set forth in Clause 414.06. No separate payment or deduction shall be

made for changes in the costs of crushing, heating, hauling or other incidentals which result from altering the ingredient proportions.

Recycled Material shall consist of existing bituminous pavement, processed such that 100% will pass the 37.5 mm (1.5 inch) sieve.

While the Contractor is required to produce the mixture from the ingredients in the approved mix design and meeting the gradation and bitumen content specified in the Job Mix Formula, he is both permitted and required to make such minor adjustments in the ingredient proportions as may be necessary to comply with the Job Mix Formula. No additional payment shall be made for differences in costs of ingredients due to such minor adjustments.

The Engineer's approval of the mix design and the Job Mix Formula shall imply only that the materials, design procedures, and results represented in the design data are acceptable. In the event that the ingredient materials vary so that the mixture cannot be maintained within the Job Mix Formula the Engineer may require that a new mix design and Job Mix Formula with different ingredients or ingredient percentages be submitted for approval and used in the remainder of the work. The Engineer may further require that the reclaimed asphalt materials be divided into coarse and fine fractions or that separate mix designs and Job Mix Formulas be utilized alternatively for the respective fractions.

414.02.1 New Ingredients

The requirements of Clauses 401 and 402 of these Specifications shall apply to all new ingredients. When cement coating is not specified, hydrated lime shall be added as an anti-stripping additive as specified in 403.02.2c of these Specifications. The Engineer may also specify the addition of silicone fluid meeting the requirements of U.S. Federal Specification VV-D-1078B, viscosity grade 1.000. The method of addition and blending of the silicone fluid, as well as the type and amount of solvent used as a dispersing medium, shall be in accordance with the directions of the manufacturer of the silicone fluid and shall be subject to the approval of the Engineer.

414.02.2 Reclaimed Asphaltic Concrete

Source of reclaimed materials for this project shall be those identified in the Contract Documents. These materials may consist of uncrushed pavement slabs stockpiled by others, stockpiled under Clause 207 of Section 2 (Earthworks) of these Specifications, or it may consist of material removed from an existing pavement by cold milling, as provided elsewhere in these Specifications. Total removal and stockpiling of existing pavement and measurement and payment therefore shall be as provided in Clauses 207.02 and 207.08 of Section 2 (Earthworks) of these Specifications.

The Contractor shall not retain reclaimed material in excess of that required for the project. Stockpiles of uncrushed salvaged material held by the Contractor upon completion of this work item shall be returned to the stockpile from which the material was obtained or shall be hauled away and stockpiled at a location to be designated by the Engineer/Employer.

The stockpile height shall not be greater than 3 meters. Construction equipment will not be permitted on the stockpiles.

The Contractor shall be responsible for preserving the quality of the reclaimed material from the Date of Enterprise.

414.02.3 Pavement Milling

This work shall consist of stripping pavement material by a cold milling process for the purpose of profiling or cleaning the surface prior to resurfacing. The work shall be performed in accordance with these Specifications and in reasonably close conformity to the dimensions and at the locations shown on the Drawings or directed by the Engineer.

A. <u>Construction</u>

The milling shall provide a surface that is free from gouges, ridges, continuous grooves and shall have a reasonably uniform surface texture acceptable to the Engineer.

Milling shall be done in a longitudinal direction. A longitudinal reference shall be provided to accurately guide the machine. Such reference for the initial pass shall consist of a kerb, edge of pavement, string attached to the pavement surface or other suitable reference as approved by the Engineer. The machine shall have a steering guide or reference that will allow the operator to follow the guidance reference within 50 mm (2 inches). When milling adjacent to previously milled pavement, the edge of the cut will serve as the longitudinal reference.

Milling shall be performed in such a manner that the termination point at the end of each day's operations shall not present a hazard of an exposed vertical edge perpendicular to the direction of travel. A transition satisfactory to the Engineer shall be provided at each end of the milling work. The longitudinal joints shall be bevelled when the pavement is to remain open to traffic.

B. Equipment

The equipment for milling shall be a power operated, self-propelled machine capable of removing a thickness of pavement necessary to provide profile, cross-fall and surface texture uniformly across the full width of the milling machine. The machine shall have sufficient power, traction, and stability to accurately maintain depth of cut and slope. An automatic system shall control grade elevations and cross-fall, be fully proportional and capable of field calibration. The system shall be capable of referencing from a towed averaging ski or a direct matching shoe.

Dust and other particulate matter created by the cutting or milling action shall be controlled in a manner acceptable to the Engineer.

The machine shall have an integral loading system or sufficient support equipment shall be provided to accomplish complete recovery of milled material at a rate equivalent to the removal rate of the milling equipment. Unless otherwise specified, the recovered milled material shall be stockpiled at locations shown on the Drawings or designated by the Engineer.

C. Tolerances

The milled surface shall not vary from a 3 meter (10 ft) straight edge placed on the surface by more than 6 mm (1/4 inch) and the discontinuity of surfaces of adjacent passes shall be limited to + 3 mm (+ 1/8 inch).

The transverse slope of the milled surface shall conform to the specified slope within 6 mm per 3 m (1/4 inch per 10 ft). Longitudinal transitions from one transverse slope to another cross-section having a different transverse slope shall be made at a uniform rate. Transitions between different depths of cut shall be at a uniform rate of 3 mm (1/8 inch) of depth per 8 meters (25 ft) of travel. The entire roadway width, when applicable, shall be milled uniformly so the cross-section of the new surface forms a straight line.

414.03 PREPARATION AND HANDLING OF SALVAGED MATERIAL

It shall be the Contractor's responsibility, while the salvaged material is in a crushed or milled condition, to handle and stockpile the material in a manner which will control lumping and consolidation, prevent segregation and contamination, and minimize waste and loss.

The crushing operation shall reduce the salvaged material to a maximum particle size (not to be confused with aggregate particle size) of 37.5 mm or to the size recommended by the manufacturer of the recycling mixing plant, whichever size is smaller.

414.04 EQUIPMENT

The equipment and processes employed in cold milling or crushing the salvaged material and in producing the recycled mixture shall be subject to the approval of the Engineer. The Engineer may require that crushing and production operations be stopped when any unit of equipment is found to be malfunctioning or in need of adjustment.

414.04.1 Equipment for Crushing Operations

The crusher shall be capable of reducing the salvaged material to the required maximum particle size while minimizing the increase in fine aggregate particles. No crusher shall be permitted for crushing salvaged asphaltic concrete which, as determined by the Engineer, increases the percent of the aggregates passing the No. 8 sieve by more than eight percent.

Crushed material shall be screened by means of a vibrating screen deck to remove all particles larger than the maximum allowable particle size and be able to divide the crushed material into coarse and fine fractions. The cold-feed system of the recycling plant shall be capable of re-blending the two fractions by means of separate hoppers as the Engineer may require for the purpose of eliminating segregations. The Contractor shall avoid segregation of the crushed materials by all appropriate measures, including minimizing free fall distance from conveyors, protecting fine material from the wind during free fall, and restricting the height of piles. In addition the Contractor shall install such devices as grizzlies, vibrators, and other apparatus as necessary to control lumping, to maintain uniform flow, and to prevent lumps larger than the maximum particle size from entering the plant.

414.04.2 Mixing Plant and Storage Bins

The mixing plant shall be of the drum-mix type and shall be capable of producing at least 200 tonnes per hour according to the manufacturer's rated capacity. It shall be a model designed or modified for recycling in accordance with the specifications and recommendations of a manufacturer experienced in supplying such equipment, and the Contractor shall make no modifications to the plant which are not in accordance with the recommendations of the manufacturer.

The mixing plant shall be equipped with a fully automated ingredient proportioning system which shall automatically regulate the introduction of bitumen into the mixture in response to continuous weighing devices in the cold feed conveyors. The flow of bitumen shall be controlled by a flow meter which shall compensate automatically for temperature and shall indicate the rate of flow. The system shall correct the weight of aggregates for moisture content either by means of automatic moisture sensing devices or by operator input of moisture content data based upon daily tests. Failure or malfunction of any component of the ingredient proportioning system or its related sensors shall be cause for rejection of the mixture. The Contractor shall not produce materials for the work when this equipment is not in full working order.

The bitumen supply system shall be insulated and shall be maintained at uniform temperature by a hot oil heating system. The temperature of the bitumen shall be regulated by an automatic control capable of maintaining the temperature within 5^{o}C of that specified.

The mixing plant shall be equipped to maintain the specified mix temperature automatically by means of temperature sensing and servo devices which shall regulate the burner which heats and dries the mixture.

The plant shall be equipped with one or more heated and insulated storage bins with a total storage capacity of at least 150 tonnes. There shall be a diverter gate or similar mechanism between the mixing drum and the storage bins by which rejected material from the mixing drum can be diverted to a waste pile. The diverter shall be actuated by a servo mechanism controlled from the operator's console. Each storage bin shall be equipped with low-bin and full-bin indicators to alert the operator when the bin has less than 20 tonnes remaining or is approaching its full capacity.

The cold feed system for new materials shall be equipped with a scalper screen to remove oversize particles.

The plant shall be equipped with not fewer than four cold feed hoppers for new aggregates. The rate of delivery from each hopper shall be continuously variable by means of a variable speed motor or an equivalent servo-actuated reciprocating feeder. Control of the proportions from individual hoppers and of the combined rate of flow shall be accomplished automatically by the ingredient proportioning system, which shall include an interlock function which shall interrupt production in the event that the supply of any ingredient is out of control.

Introduction of mineral filler into the mixture may be accomplished by injecting it into the mixing zone of the drum or by delivery to the cold feed belt. In either case the rate of delivery shall be fully regulated by the ingredient proportioning system, and the metering and delivery mechanism shall be calibrated along with the cold feed control.

Mineral filler and dust collector fines may be combined in one conduit for injection into the mixing drum; however the mineral filler shall be metered independently of the dust collector fines. Provision shall be made to waste all or part of the dust collector fines as the Engineer may require.

414.04.3 Truck Scales

The plant shall be equipped with a truck scale of sufficient size and weighing capacity to weigh any loaded truck

delivering materials to the plant or hauling the mixture to the project site. The scale shall be accurate within 20 kg of the true weight of any load within its rated capacity. It shall be situated near the plant entrance. All components except the weighing platform shall be housed in an enclosed scale house. The scale shall also be equipped with an automatic device to provide a printed record of each weighing.

414.05 CONTROL OF RECYCLED MIXTURES

The completed mixture shall conform to the Job Mix Formula approved by the Engineer. The Job Mix Formula shall be based upon the results of a complete Marshall mix design analysis carried out by the Contractor and verified and approved by the Engineer.

The Contractor shall carry out regular quality control sampling and testing of the ingredients and the complete mixture and shall be responsible for calibrating the plant and adjusting the ingredient percentages so as to maintain the mixture in conformity to the Job Mix Formula within the tolerances established under Table 414.05.3. In addition to testing the mixture for acceptance, the Engineer may carry out further sampling and testing and may, on an advisory basis, provide the Contractor with test results and ingredient percentages based upon analysis of the mixture and the ingredient materials. The Contractor is not obligated to make adjustments according to the data which the Engineer may provide, and his use of such data does not relieve him of the responsibility for the quality of the mixture.

414.05.1 Mix Design Analysis

The provisions of Clause 404.02.3 of these Specifications shall apply with the following additions and modifications: At least one month before the start of paving operations the Contractor shall deliver to the Engineer the results of a complete Marshall mix design study of the materials to be used in the work. The proposed mix design shall meet the criteria established in Clause 404.02.3 of these Specifications for Type 1 Base Course, as modified by Clause 411.02.2 of these Specifications for cement-coated aggregates and the gradation shall be within the design limits of Table 414.05.1.

Sieve size mm	Gradation Limits - % Passing by Weight
37.5mm (1 ½ inch)	100
25.0 mm (1 inch)	82 - 100
19.0 mm (¾ inch)	70 - 100
12.5 mm (½ inch)	54 - 84
9.5 mm (3/8 inch)	44 - 74
4.75 mm (No. 4)	30 - 58
2.36 mm (No. 8)	22 - 45
1.18 mm (No. 16)	15 - 36
0.60 mm (No. 30)	10 - 28
0.30 mm (No. 50)	6 - 22
0.15 mm (No. 100)	4 - 14
0.075 mm (No. 200)	2 - 8
Asphalt cement content (percent by weight of aggregates)	3.5 - 5.5

Table 414.05.1 – Mix Design Limits for Recycled Asphalt Base

The design study shall include the results of the gradation analysis, voids and density analysis, and graphing of the curves for density, air voids, stability and flow. This information together with the results of AASHTO T165 and all necessary calculations shall be provided for the mix design proposed. Values for gradation and asphalt content of the reclaimed material in all design calculations shall be the averaged results of not less than ten extraction analyses of random samples of the crushed or milled material. Individual results of these extractions shall be included also in the data submitted to the Engineer.

The mix design proposed by the Contractor shall be subject to verification by the Engineer. The design shall be verified by repeating the Marshall design procedure at selected asphalt contents using recent samples of the

materials. The Engineer shall approve the mix design when the results obtained confirm that it meets the design criteria. In the event that the results obtained by the Engineer do not meet the design criteria, the Contractor shall submit a new mix design.

414.05.2 Job Mix Formula

The Job Mix Formula shall be established and approved as set forth in Clause 404.02.4 of these Specifications. Allowable tolerances for acceptable of the mixture shall be those given in Clause 414.05.3 of these Specifications which sets forth the lot pay factors.

The Contractor may, at any time after production begins, submit a revised Job Mix Formula for the Engineer's consideration. He shall submit a revised Job Mix Formula when adjustment of the asphalt content is warranted, when the mix temperature should be changed to improve laydown, when special additives, especially silicone, are to be added, or when the materials deviate slightly in average gradation from the design values. Subject to the Engineer's prior approval, minor adjustments to the Job Mix Formula may be made without a new mix design, provided that the adjustment shall not deviate from the approved mix design by more than the tolerance allowed in Table 414.05.2.

When a gradation trend in the ingredient materials is detected which causes the combined gradation to exceed one or more of the allowable adjustments, the Job Mix Formula will be cancelled and a new approved mix design and Job Mix Formula will be required.

Sieve, mm	Tolerance (Plus or Minus) %
25.0 (1 inch)	4
12.5 (1/2 inch)	4
9.75 (3/8 inch)	4
4.75 (No. 4)	4
2.36 (No. 8)	3
1.18 (No. 16)	3
0.60 (No. 30)	2
0.30 (No. 50)	2
0.15 (No. 100)	2
0.075 (No. 200)	2
Asphaltic Cement	0.2

Table 414.05.2 - Allowable Adjustments of Job Mix Formula

414.05.3 Mixture Acceptance

Conformity of the mixture to the Job Mix Formula shall be determined by extraction analysis or other standard tests of representative samples of the mixture. Samples may be taken from the haul vehicles upon leaving the mixing plant, from the compacted material immediately after it is spread, or from samples cut from the compacted layer. All samples shall be obtained according to a random method without regard to appearance of the mixture or other factors.

The mixture shall be accepted in lots. Each lot shall consist of one day's production, except that when less than 500 tonnes is produced in a day and production is resumed the following day, the first day's production shall be included with the lot of the following day.

Mixture acceptance tests shall be made on each lot. The number of tests per lot shall be determined by the lot size as follows:

Lot sizes (tonnes)	No. of tests
0 to 500	2
500 to 750	3
750 to 1000	4
1000 to 1500	5
More than 1000	6

Results of each sample shall be compared with the Job Mix Formula. The deviations from the values in Job Mix

Formula for asphalt cement content and for the percent passing the 12.5mm, 2.36mm, 0.60mm and 0.15mm sieves shall be averaged for all the tests in one lot, and the average deviation for each of these criteria shall be compared with the tolerances in Table 414.05.3 to establish the Lot Pay Factor. Deviations shall be averaged absolutely, without regard to their algebraic signs. The Lot Pay Factor shall be the mathematical product of the pay factor for asphalt cement content multiplied by the single lowest pay factor of the four designated sieves.

A lot may be accepted at the full Contract price, accepted at a reduced prices, or rejected. A lot shall be accepted at full price when all of its average deviations from the Job Mix Formula are within the respective tolerances for pay factor of 1.0. If a lot does not meet the tolerances for a pay factor of 1.0 but meets the tolerances for a lower pay factor in the table, it may be accepted at a reduced price if the Lot Pay Factor is 0.5 or higher and if, in the judgment of the Engineer, its inclusion in the work would be less detrimental to the project than removal. The reduced price to be paid for that lot shall be the Contract price times the Lot Pay Factor. Any lot which does not meet the tolerances for the lowest pay factor for any one of the test criteria, or which has a Lot Pay Factor less than 0.50 shall be rejected, and the Contractor shall remove and replace the entire lot with acceptable material at his own expense.

One additional sample shall be tested if, in a given lot of less than 1500 tonnes, the range (difference between) the highest and lowest test results for any criterion in Table 414.05.3 is more than the upper limit for a pay factor of 0.5 for two tests. Both the original tests and the additional test shall be counted to determine the appropriate tolerances in Table 414.05.3.

Acceptance Criterion	Pay Factor	Number of Tests				
		2	3	4	5	6
		Average Deviation from the Job Mix Formula				
Bitumen Content Percent	1.0	0.00 - 0.61	0.00 - 0.54	0.00 - 0.48	0.00 - 0.43	0.00 - 0.39
	0.9	0.62 - 0.68	0.55 - 0.60	0.49 - 0.53	0.44 - 0.48	0.40 - 0.43
	0.8	0.69 - 0.74	0.61 - 0.65	0.54 - 0.58	0.49 - 0.52	0.44 - 0.48
	0.7	0.75 - 0.79	0.66 - 0.69	0.59 - 0.62	0.53 - 0.56	0.49 - 0.51
	0.6	0.80 - 0.82	0.70 - 0.73	0.63 - 0.66	0.57 - 0.59	0.52 - 0.53
	0.5	0.83 - 0.85	0.74 - 0.76	0.67 - 0.68	0.60 - 0.61	0.54 - 0.55
Percent Passing 12.5mm (1/2") Sieve	1.0	0.0 - 8.1	0.0 - 7.2	0.0 - 6.4	0.0 - 5.7	0.0 - 5.0
	0.9	8.2 - 9.6	7.3 - 8.4	6.5 - 7.4	5.8 - 6.5	5.1 - 5.7
	0.8	9.7 - 11.1	8.5 - 9.6	7.5 - 8.3	6.6 - 7.2	5.8 - 6.3
	0.7	11.2 - 12.5	9.7 - 10.7	8.4 - 9.2	7.3 - 7.9	6.4 - 6.8
	0.6	12.6 - 13.8	10.8 - 11.8	9.3 - 10.1	8.0 - 8.6	6.9 - 7.3
	0.5	13.9 - 15.0	11.9 - 12.8	10.2 - 10.9	8.7 - 9.2	7.4 - 7.7
Percent Passing 2.36mm (No. 8) Sieve	1.0	0.0 - 6.3	0.0 - 5.4	0.0 - 4.8	0.0 - 4.4	0.0 - 4.1
	0.9	6.4 - 7.0	5.5 - 6.0	4.9 - 5.3	4.5 - 4.9	4.2 - 4.5
	0.8	7.1 - 7.7	6.1 - 6.6	5.4 - 5.8	5.0 - 5.3	4.6 - 4.9
	0.7	7.8 - 8.5	6.7 - 7.2	5.9 - 6.4	5.4 - 5.8	5.0 - 5.3
	0.6	8.6 - 8.8	7.3 - 7.5	6.5 - 6.8	5.9 - 6.2	5.4 - 5.7
	0.5	8.9 - 9.1	7.6 - 7.8	6.9 - 7.2	6.3 - 6.6	5.8 - 6.1
Percent Passing 0.60mm (No. 30) Sieve	1.0	0.0 - 3.9	0.0 - 3.5	0.0 - 3.2	0.0 - 3.0	0.0 - 2.8
	0.9	4.0 - 5.1	3.6 - 4.5	3.3 - 4.1	3.1 - 3.8	2.9 - 3.5
	0.8	5.2 - 6.2	4.6 - 5.5	4.2 - 4.9	3.9 - 4.5	3.6 - 4.1
	0.7	6.3 - 7.2	5.6 - 6.4	5.0 - 5.7	4.6 - 5.1	4.2 - 4.6
	0.6	7.3 - 8.1	6.5 - 7.1	5.8 - 6.3	5.2 - 5.6	4.7 - 5.1
	0.5	8.2 - 8.8	7.2 - 7.7	6.4 - 6.8	5.7 - 6.1	5.2 - 5.5
Percent Passing 0.15mm (No. 100) Sieve	1.0	0.0 - 2.8	0.0 - 2.4	0.0 - 2.1	0.0 - 1.8	0.0 - 1.6
	0.9	2.9 - 4.1	2.5 - 3.6	2.2 - 3.1	1.9 - 2.7	1.7 - 2.4
	0.8	4.2 - 5.3	3.7 - 4.7	3.2 - 4.2	2.8 - 3.6	2.5 - 3.1
	0.7	5.4 - 6.4	4.8 - 5.7	4.3 - 5.1	3.7 - 4.4	3.2 - 3.8
	0.6	6.5 - 7.5	5.8 - 6.6	5.2 - 5.9	4.5 - 5.1	3.9 - 4.4
	0.5	7.6 - 8.5	6.7 - 7.5	6.0 - 6.6	5.2 - 5.7	4.5 - 4.9

Table 414.05.3 - Tolerances for Mixture Acceptance

The Engineer may at his discretion, order that additional samples be taken in order to increase the statistical accuracy of the averaged results. Test results for the additional samples shall be compared with the Job Mix

Formula and their absolute deviations shall be averaged with the previous values. Both the original tests and the additional tests shall be counted to determine the appropriate tolerances in Table 414.05.3.

When the mixture is found to be running out of tolerance or when the mix temperature varies by 10°C (18°F), either from one truck load to the next or from the Job Mix Temperature, production shall be stopped until the necessary corrective measures have been taken and the Engineer approves restarting the plant. Individual truckloads which prior to discharging are found not to meet the above temperature requirements to which are found upon visual inspection to contain badly segregated or poorly mixed material shall be rejected The load ticket shall be marked with the word "Rejected" and the truck shall not be permitted to discharge at the project site

In the event that poorly mixed or contaminated material is observed in the storage bins or in the discharge from the drum, the Engineer shall have cause to reject the entire contents of the bin as well as the load or loads in which the defective material is detected. In such a case the storage bin shall be emptied completely and the material disposed of before production may continue.

414.06 MEASUREMENT AND PAYMENT

414.06.1 Method of Measurement of Recycled Asphalt Pavement Courses

Measurement of recycled asphalt concrete pavement courses shall be by meter square for the various types and thickness required in accordance with the Drawings, Specifications or as directed by the Engineer, and shall be calculated from the top surface area, excluding tapered edges which shall be included in the rates.

414.06.2 Method of Measurement of Extra or Less New Materials

Extra or less new aggregates and asphalt cement shall each be measured by weight and the net difference for each new material shall be paid by or credited to the Employer, as appropriate.

414.06.3 Method of Measurement of Pavement Milling

Pavement milling shall be measured by the meter square of the existing roadway surface (excluding tapered edges) milled to the depths as specified in the Drawings, Specifications or as directed by the Engineer.

414.06.4 Method of Payment for Recycled Asphalt Concrete Pavement Courses

Payment for recycled asphalt concrete courses constructed in accordance with these Specifications shall be at the rate for the respective type of mix as shown in the Bills of Quantities. The rates shall be all inclusive of the materials, equipment and labour necessary for the proper completion of the work in accordance with these Specifications.

Where new road construction work adjoins or meets existing road construction, e.g. new shoulders and cross-roads, no separate payment will be made for cutting back the edges of the existing construction to receive the new surfacing layers, the cost being included with the cost of the recycled surfacing courses.

Rates applicable to recycled asphalt accepted at a reduced price under Clause 414.05.3 hereof shall be determined by the multiplying the Contract unit rate for the recycled asphalt course concerned by the Lot Pay Factor.

414.06.5 Method of Payment for Extra New Materials/Credit for Less New Materials

Payment to the Contractor for extra new materials or credit to the Employer for less new materials shall be at the rates shown in the Bills of Quantities. Such rates shall include for all materials, labour and equipment necessary for the provision of such extra materials in accordance with these specifications.

The payment for new aggregates shall only apply for the amount of extra new aggregates exceeding 70% of the total weight of aggregate, as ascertained from the currently approved Job Mix Formula. Similarly, credit for new aggregates shall only apply for the amount of new aggregates less than 60% of the total weight of aggregates, ascertained by the same method.

The payment for new asphalt cement shall only apply for the amount of extra new asphalt cement exceeding 3.2% of the total weight of aggregates, as ascertained from the currently approved Job Mix Formula. Similarly, credit for new asphalt cement shall only apply for the amount of new asphalt less than 2.2% of the total weight

of aggregates, ascertained by the same method.

414.06.6 Method of Payment for Pavement Milling

Pavement shall be at the rate in the Bills of Quantities which payment shall include for all labour, equipment and materials for pavement milling and to deliver the recovered material to the designated location.

414.06.7 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
414.1	Recycled Asphalt Concrete Pavement (Type, Thickness)	sq.m
414.2	Extra New Aggregates /Credit New Aggregate	t
414.3	Extra New Asphalt Cement /Credit New Asphalt Cement	t
414.4	Pavement Milling (Depth)	sq.m

415 - SURFACE RIDEABILITY MEASUREMENT

415.01 DESCRIPTION

This Sub-Section summarizes testing procedures and road surface rideability specifications for asphalt surfaced pavements. The specifications are based on the International Roughness Index (IRI) values (average value from three runs and in units of m/km) measured using a high-speed profiler tugged by a utility vehicle. A minimum lead-in distance of 100 m and a segment length of 150 m are suggested.

415.02 REFERENCE DOCUMENTS FOR PROFILER RIDEABILITY TESTING

i. ASTM E 867 Terminology Relating to Vehicle-Pavement Systems.

ii. ASTM E 950 Test Method for Measuring Pavement Roughness Using a Profiler.

iii. AASHTO Designation PP 50-02: Standard Equipment Specification for an Inertial Profiler.

iv. AASHTO Designation PP 51-02: Standard Practice for Certification of Inertial Profiling System.

v. AASHTO Designation PP 52-02: Standard Practice for Operating Inertial Profilers and Evaluating Pavement Profiles.

vi. AASHTO Designation PP 53-02: Standard Practice for a Pavement Ride Quality Specification when Measured Using Inertial Profiling System.

415.03 TERMINOLOGY

The current rideability specifications are based on International Roughness Index (IRI). As an internationally accepted scale for ride quality, IRI is a standardized measure of the response of a standard vehicle to pavement profile. IRI is an index computed from a single longitudinal profile using a quarter-car model at a simulated travel speed of (80 km/h). Lane IRI is the average of the left and right wheel path IRI values.

415.04 TESTING EQUIPMENT

The rideability testing shall be conducted using a high-speed profiler (HSP). The HSP should conform to the requirements of Class I equipment as defined in ASTM E 950 and to the requirements specified in AASHTO Designation PP 50-02 and PP 51-02.

Prior to testing, calibration and verification procedures should be in accordance with the recommendations provided by the profiler manufacturer. The equipment should be operated in accordance with the recommendations provided by the manufacturer and AASHTO PP 52-02.

415.05 TESTING PROCEDURE

Continuous and rigorous scrutiny of profiler output is required. A constant testing speed should be maintained through the lead-in distance (100 m minimum) and the test section. Two driving speeds of 65 to 95 km/h are

required.

The profiles measured for each run should be used to compute the IRI value for each wheel path of each 150m subsection within the test section. After three runs, the test data (IRI values) should be reviewed by calculating the average, standard deviation, and coefficient of variance (COV) for each subsection wheel path. If a value of standard deviation is greater than 0.016m/km or COV is greater than 5%, then the test shall be repeated. Additional testing should be done until standard deviation is less than 0.016m/km or COV is less than 5% (with obvious outliers excluded).

After five runs, if a value of standard deviation is larger than 0.016 m/km or COV is greater than 5%, compare the profiles from the five runs and attempt to identify possible equipment or operational problems. Recalibrate if necessary. Record all data.

415.06 SUBMITTALS

Data for each test should be stored on media such as CD.

Hard copy reports should be provided for each test section. The following information be reported and stored:

i. Date and time of day.

ii. Operator(s) and equipment used.

iii. Weather conditions: temperature, cloud cover, and wind.

iv. Surface description: type of pavement and condition.

v. Location and description of section: Job ID, lane, beginning and ending stationing (or other location information), and direction.

vi. Total section length.

vii. Data filter settings: High-pass filter setting = 100m.

viii. IRI value of each wheel path and the average of the two wheel paths for each 150 m subsection.

ix. Raw data.

415.07 REQUIRED RIDEABILITY

For the rideability test evaluation, each lane of the road shall be divided into 150m long subsections. The average IRI value shall be taken for two wheel paths (lane IRI) for each 150m subsection.

The average international Roughness Index (IRI) value representing the rideability of each road subsection shall not exceed 1.2 m/km. However, 20% of the values obtained for each subsection are tolerated to vary in the range of 1.3 – 2.4 m/km, with no single value exceeding 2.4 m/km and at least 80% of the values are less or equal to 1.2 m/km. Wherever any of the requirements specified above is not met, the top asphalt wearing course layer shall be milled out, removed and replaced by new asphalt wearing course layer complying with the specification requirements, at the Contractor's own expenses.

415.08 MEASUREMENT AND PAYMENT

415.08.1 Method of Measurement and Basis of Payment

The IRI test shall be measured in linear meter for the total length of pavement tested and accepted in each pavement lane (covering two wheel paths per lane), including testing equipment, calibration, interpretation of data and reporting of results.

The amount of completed and accepted work, measured as provided for above, will be paid for at the unit rates for the various items in the Bills of Quantities , which rate shall be full compensation for labor, equipment, tools, materials, transportation and other items necessary for the proper completion of the work.

415.08.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
415.1	International Roughness Index (IRI) Test	m

SECTION 5: CONCRETE WORKS

500 - GENERAL

500.01 DESCRIPTION

This Section contains Specifications for concrete work which consists of preparing concrete mixes of the different classes; transporting and placing on prepared surfaces or in prepared forms, including supplying and fixing of formwork and temporary work; supplying, cutting, bending and placing of reinforcing steel, vibrating, tamping and curing, supplying and installing precast units, including bedding, pointing and jointing with cement mortar all in accordance with these Specifications and in conformity with Drawings.

Concrete specified in this Section 5, Concrete Works, applies to all concrete structures and also to Section 11, Prestressed Concrete Works, which covers precast and cast-in-place, pre-tensioned and post-tensioned concrete superstructures.

501 - MATERIALS AND TESTING

501.01 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

A 36	Structural Steel
A 82	Standard Specification for Steel Wire (Plain) for Concrete Reinforcement.
A 615	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
A 951	Standard Specification for Masonry Joint Reinforcement
A 153	Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
C 33	Concrete Aggregate
C 39	Compressive Strength of Cylindrical Concrete Specimens
C 40	Organic Impurities in Sand for Concrete
C 87	Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
C 88	Soundness of Aggregates by use of Sodium Sulphate and Magnesium Sulphate
C 117	Test Method for Materials Finer than 0.075 mm (No.200) Sieve in Mineral Aggregates by Washing
C 123	Lightweight Pieces in Aggregate
C 136	Sieve or Screen Analysis of Fine and Coarse Aggregates
C 140	Concrete Masonry Units – Sampling and Testing
C 150	Portland Cement
C 151	Standard Test Method for Autoclave Expansion of Hydraulic Cement
C 186	Standard Test Method for Heat of Hydration of Hydraulic Cement
C 204	Standard Test Methods for Fineness of Hydraulic Cement by Air-Permeability Apparatus
C 227	Potential Alkali reactivity for Cement Aggregate Combinations, (Mortar Bar Method)
C 289	Standard Test Method for Potential Reactivity of Aggregates (Chemical Method)
C 295	Standard Practice for Petrographic Examination of Aggregates for Concrete
C 309	Liquid Membrane – Forming Compounds for Curing Concrete
C 494	Chemical Admixtures for Concrete
C 586	Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method)
C 881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
D 543	Test Resistance of Plastics to Chemical Reagents
D 570	Standard Test Method for Water Absorption of Plastics
D 624	Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
D 638	Standard Test Method for Tensile Properties of Plastics
D 822	Practice, Water and Light Exposure Test, Paint, Varnish
D 1000	Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
D 1004	Standard Test Method for Initial Tear Resistance of Plastic Films and Sheeting

D 1654	Evaluation of Coated Specimens Exposed to Corrosive Environs
D 1712	Test, Resistance of Plastics to Sulphide Staining
D 1751	Preformed Expansion Joint, Fillers for Concrete Paving and Structural Construction
D 2244	Evaluation of Color Differences
D 3134	Practice for Defining Color and Gloss Tolerances
D 3406	Joint Sealants, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements
D 5385	Standard Test Method for Hydrostatic Pressure Testing of Waterproofing Membranes
D 6690	Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
E 8	Tension Testing of Metallic Materials
E 96	Standard Test Methods for Water Vapor Transmission of Liquids
E 154	Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

AASHTO

AASHTO LRFD	Bridge Construction Specifications
AASHTO LRFD	Bridge Design Specifications
M 6	Fine Aggregate for Portland Cement Concrete
M 31	Deformed and Plain Billet Steel Bars for Concrete Reinforcement
M 92	Wire Cloth for Testing Purposes
M 148	Liquid Membrane – Forming Compounds for Curing Concrete
M 153	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
M 157	Ready Mixed Concrete
M 213	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction
T 2	Sampling Stone, Slag, Gravel, Sand and Stone Block for Use in Highway Materials
T 26	Standard Method of Test for Quality of Water to be used in Concrete
T 68	Tension Testing of Metallic Materials
T 96	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
T 119	Slump of Portland Cement Concrete
T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
T 277	Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

BS

BS 188	Methods for Determining the Viscosity of Liquids
BS EN 196	Methods of Testing Cement
BS EN 197-1, Part 1	Portland Cement
BS 410	Test Sieves
BS 812(1975)	Methods for Sampling and Testing of Mineral Aggregates, Sands and Fillers
BS 890	Building Limes
BS EN 1008 2002	Mixing Water for Concrete
BS 1199	Building Sands From Natural Sources
BS 1243	Metal Ties for Cavity Wall Construction
BSI BS EN 1339	Concrete paving flags Requirements and test methods
BSI BS EN 1340	Concrete kerb units Requirements and test methods
BS 1881	Methods for Analysis of Hardened Concrete
BS 2499	Hot Applied Joint Sealants for Concrete Pavements
BS 3148	Method of Testing for Water for Making Concrete
BS 4027	Specification for Sulfate-Resisting Portland Cement
BS 4466	Bending Dimensions and Scheduling of Reinforcement for Concrete
BS 4483	Steel Fabric for Reinforcement of Concrete
BS 5135	Metal-Arc Welding of Carbon and Carbon Manganese Steels
BS 5212	Cold Poured Joint Sealants for Concrete Pavements
BS 7533	Pavement Construction with Clay, Natural Stone or Concrete Pavers
BS 8007	Code of Practice for the Structural Use of Concrete for Retaining Aqueous
BS 8102	Code of Practice for Protection of Structures Against Water from the Ground

BS EN 12350	Testing Fresh Concrete
BS EN 12390	Testing Hardened Concrete
BS EN 12504	Testing Concrete in Structures
BS EN 12620	Aggregate from Natural Source for Concrete

CODES OF PRACTICE

114 Structural Use of Reinforced Concrete in Buildings (Metric Units)

MINISTRY OF PUBLIC WORKS (MPW)

MPW Test for Soft and Friable Particles (MESH)
MPW Test for Water Soluble Chlorides and Sulphates in Graded Aggregates

FEDERAL SPECIFICATION

MMM-B-350A	Epoxy Concrete Adhesive
TT-S-277	Sealing Compound, Rubber Base, Two-Component
SS-S-200E	Sealants, Joint, Two-Component Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

ACI

ACI-305	Hot Weather Concreting
ACI-315	Manual of Standard Practice for Detailing Reinforced Concrete Structure
ACI-347	Formwork Design

DIN

DIN 1045	Reinforced Concrete Structures Design and Construction
DIN 1048	Regulations for Testing Concrete Used During Erection of Concrete and Reinforced Concrete Structures (Water Tightness Test).

BRE DIGEST

35 Shrinkage of Natural Aggregates in Concrete
Special Digest 1:2005 Concrete in Aggressive Ground

KUWAIT STANDARD SPECIFICATIONS

KSS 222
KSS 223

501.02 SAMPLES

The Contractor shall furnish samples of all materials for source approval by the Engineer. The Contractor, at his expense, shall provide the equipment, operators and safe, suitable facilities as required for the Engineer to obtain samples and shall perform all testing of materials as specified herein.

501.03 FINE AGGREGATE

Fine aggregate for Portland cement concrete shall consist of natural sand in accordance with ASTM C33.

Water soluble chlorides in the fine aggregate shall not exceed 250 parts per million and water soluble sulfates shall not exceed 1300 parts per million as determined by the standard MPW test for water test for water soluble chlorides and sulfates present in graded aggregates.

When aggregate is subjected to five cycles of the sodium sulfate soundness test (ASTM C88), the loss shall not exceed 10% by weight.

The gradation of fine aggregate used in Portland cement concrete shall be in accordance with Table 501.03 (a).

Sieve Designa	ASTM Alternative	Percent Passing
mm		(by weight)
9.5	9.5 mm (3/8 inch)	100
4.75	4.75 mm No. 4	90 - 100
2.36	2.36 mm No. 8	80 - 100
1.18	1.18 mm No. 16	60 - 90
600 µ	0.60 mm No. 30	35 - 70
300 µ	0.30 mm No. 50	5 - 30
150 µ	0.15 mm No. 100	0 - 10

Table 501.03 (a) Gradation of Fine Aggregate for Concrete Works

The percent passing the 0.075 mm (No. 200) Sieve shall not exceed 3%. The sand equivalent as determined by AASHTO T176 shall not be less than 50%.

The fine aggregate shall be of such uniformity that the fineness modulus as defined in ASTM C33 shall not vary more than 0.20 either way from the fineness modulus of the representative samples used in the mix design.

The amount of deleterious substances shall not exceed the following limits when tested in accordance with ASTM C33:

Percent by Substance	**Weight**
Soft and Friable Particles	1.0
Coal and Lignite	0.5
Material finer than a No.200 sieve	3.0

Mortar specimens made with the proposed fine aggregate, when tested in accordance with ASTM C87, shall have an average compressive strength of at least 90% of the strength of similar specimens made with the same cement and Ottawa sand.

501.04 COARSE AGGREGATE

Aggregates shall meet the requirements of ASTM C33. Gradation:

Reinforced Concrete		**Prestressed Concrete and Reinforced Concrete where**	
Sieve Size	Percent Passing (By Weight)	Sieve Size	Percent Passing (By Weight)
37.5mm	100	25mm	100
25mm	90-100	19mm	90-100
12.5mm	25-60	12.5mm	30-70
4.75mm	0-10	4.75mm	0-10

Table 501.04 - Gradation of Coarse Aggregate in Concrete

The amount of deleterious substances shall not exceed the following limits:

Substance	**Allowance**
Soft and friable particles (mesh)	Reinforced concrete 3%
in combined aggregate (MPW Test Method)	Prestressed concrete 2%
Materials finer than a 75µm (No.200 Sieve) (ASTM C117)	1%
Flakiness (individual stockpiles) BS 812 (1975)	25%

The percentage of wear of the aggregate shall not be greater than 50 as determined by AASHTO T96.

When the coarse aggregate is subjected to five cycles of the sodium sulphate soundness test (ASTM C88), the loss shall not exceed 12 per cent by weight.

Water soluble chlorides in the coarse aggregate shall not exceed 250 parts per million and water soluble sulphates shall not exceed 1300 parts per million as determined by the standard MPW test for water soluble chlorides and sulphates present in graded aggregates.

501.04.1 Potential Aggregate – Cement Reactivity

Notwithstanding the requirements of Clause 501.06.1 of these Specifications the Contractor shall carry out petrographic analyses in accordance with ASTM C33 and C295 for all imported aggregates proposed for use. If this examination reveals materials known to be potentially reactive the Contractor shall perform further tests in accordance with ASTM C289 and BRE Digest No. 35; also in accordance with ASTM C227, and C586 if the Engineer so decides after his examination of the preceding tests.

In the event that tests in accordance with ASTM C227 are called for the cement used in the test shall have an alkali content (expressed as sodium oxide + 0.658 potassium oxide) greater than 0.6% by weight and the mortar bars shall have an aggregate/cement ratio by weight of 2.25 to 1.0.

It shall be noted that the ASTM C227 tests may need to extend over a period of six months and should therefore be commenced early in the contract period.

The above tests will not be measured and paid for, and all costs of carrying out the tests including providing samples and equipments and submitting test results to the Engineer shall be deemed to be covered by the various rates inserted in the Bills of Quantities.

501.05 WATER FOR CONCRETE MIXES AND CURING

Unless otherwise authorized in writing by the Engineer, only water from the potable supply system of Kuwait may be used for mixing concrete and other products containing cement. Similarly, only potable water may be used for curing concrete and cement products, for ice production and for washing aggregates. The water used must at all times comply with the requirements of BS 3148 and shall be tested in accordance with AASHTO T26.

The water shall enter the mixers at as low a temperature as possible. Every effort should be made to protect water pipes and tanks from the sun, e.g. by burying, shading, insulating or painting white.

The pH of water used in concrete works shall be not less than 6.0 nor more than 8.0.

501.06 CEMENT

501.06.1 Cement-Type

Cement shall be of the type specified in the Contract Documents Out of the following types:

i. Ordinary Portland cement (OPC) conforming to ASTM C 150 Type I or BS EN 197. The heat of hydration shall not exceed 325 kj/kg when tested in accordance with ASTM C 186. C_3A content shall be a minimum of 8 percent and a maximum of 13 percent.

ii. Sulfate-resisting Portland cement conforming to ASTM C 150, Type V or BS 4027, C_3A content shall not be more than 3.5 percent.

iii. Moderate Sulfate conforming to ASTM C 150 type II or BS EN 197. C_3A content shall be a minimum of 3.5 percent and a maximum of 8 percent.

One brand of cement as approved by the Engineer shall be used for all concrete works throughout the project unless otherwise authorized by the Engineer in writing.

The acid-soluble alkali content of the cement, expressed as equivalent sodium oxide and calculated as Na20 + 0.658K20, shall be less than 0.6% by weight.

Sampling shall be carried out in accordance with BS EN 196: Part 7. Test cement for fineness by air permeability apparatus in accordance with ASTM C 204 to meet the requirements of ASTM C 150. Test cement for soundness, Autoclave expansion in accordance with ASTM C151.

The source of supply of cement shall be subject to the Engineer's approval and the Contractor shall at all times furnish the manufacturer's test certificates and proof that the required Specification has been complied with, together with a note of the date of manufacture, certified by an independent agency in the country of origin. The Engineer shall have the power to reject a part of the whole of any consignment of cement if he considers it to be unsuitable for use in the works.

501.06.2 Cement-Storage

Cement shall be delivered to the site in bulk, or with the Engineer's approval cement may be supplied in sealed bags which shall bear the manufacturer's name and the date of manufacture. Bulk cement shall be stored in perfectly dry waterproof bins or hoppers; bagged cement shall be stored in perfectly dry waterproof sheds or other such temporary buildings approved by the Engineer. Such sheds or buildings shall be used exclusively for the storage of cement and shall be erected with the floors raised well above the ground at places on or near the Site of the Works; and at the completion of the Works the buildings shall remain the property of the Contractor and shall be dismantled and removed, the foundations broken up and the site restored to its original condition.

A free passage of at least one meter shall be left between the cement and the side walls of the sheds. Access ways shall also be left between the stored bags of cement such that every bag is visible. Each consignment of cement shall be stored apart from earlier consignments and consignments shall be used in the order in which they are delivered.

The Contractor shall provide weighing machines which shall be kept permanently in each shed or building for checking the weight of the bags of cement.

The Engineer shall have access at all times to the cement storage bins, hoppers, sheds or buildings.

Any consignment of cement which has become caked or otherwise adversely affected shall be removed from the site immediately at the Contractor's own expense.

During transport and storage the cement shall be fully protected from all weather elements. The temperature of the cement entering the mixers shall not exceed 45°C.

501.07 REINFORCING STEEL

All reinforcing steel bars shall comply with the requirements of AASHTO M31 (ASTM A-615) and the minimum requirements of Table 501.07 and shall be Grade 60 deformed billet steel bars or Grade 40 plain billet steel bars as shown on the Drawings or as instructed by the Engineer. Testing shall be in accordance with AASHTO T68 (ASTM E8). Spiral reinforcing steel shall meet the requirements of ASTM A82.

501.08 MESH REINFORCEMENT

Mesh or fabric reinforcement shall comply with the requirements of British Standard BS 4483. Alternatively a mesh may be fabricated on site from individual bars complying with Clause 501.07 of these Specifications. In this case bars shall be of the same diameter and at the same centres as the mesh. The bars shall not be welded, but securely tied at each intersection.

Steel fabric reinforcement shall be delivered to the works in flat mats only.

Property	Grade 40	Grade 60
Tensile strength min kg/cm^2	4921	6327
Yield, min kg/cm^2	2812	4218
Elongation in 200mm , min, %		
Bar Size mm		
10-	11	9
12+	12	9
16-	12	9
20-	12	9
22+	11	8
24+	10	8
28+	9	7
30+	8	7

Table 501.07 – Minimum Requirements for Intermediate Tensile and Mild Steel Reinforcement

501.09 CORROSION INHIBITOR

For all reinforced concrete structures use corrosion inhibitor MCI-2005. The material shall be incorporated in the concrete mix in strict accordance with the manufacturer's instructions.

502 - CLASSES OF CONCRETE

502.01 MIXES

Concrete to be used shall have the mix designations and strength requirements shown in Table 502.01 herein.

At the time of placing the concrete the slump shall not be less than 40 mm nor greater than 120 mm unless otherwise agreed with the Engineer.

Except as otherwise provided for in Clause 507 of these Specifications, BS EN 12390, Parts 1, 2, 3, 4, and 7, Testing Hardened Concrete, shall govern for the manufacture and testing of compressive strength test cubes for all classes of Concrete.

Brirish European Standard Specifications BS EN

Acceptance of the work will be based on 28 day cube strengths as determined under Clause 507 of these Specifications.

Requirement		Class of Concrete								
		K140	**K180**	**K250**	**K300**	**K350**	**K415**	**K450**	**K500**	**K600**
Minimum crushing strength kg./cm^2 Preliminary Test Cubes at 7 days		140	180	250	300	350	415	450	500	600
Minimum crushing strength kg./cm^2 Work Test Cubes at 7 days		100	140	185	220	260	310	330	375	450
Minimum crushing strength kg./cm^2 Preliminary Test Cubes at 28 days		175	225	325	400	440	500	540	600	700
Minimum crushing strength kg./cm^2 Work Test Cubes at 28 days		140	180	250	300	350	415	450	500	600
Minimum crushing strength kg./cm^2 Work Test Cylinders at 28 Days		105	140	190	225	280	300	350	400	500
Water/cement ratio* (max.)		0.70	0.70	0.60	0.55	0.50	0.45	0.42	0.40	0.38
Minimum cement content kg./m^3		220	220	300	380	400	425	450	450	450

* Based on total free water available for hydration.

Table 502.01 – Requirements of Different Classes of Concrete

502.02 USES OF DIFFERENT CLASSES OF CONCRETE

The concrete class to be used for the different elements shall be as defined in the Contract Documents subject to the minimum values set in the Highway Design Manual. Concrete Class K 180 shall be used for non-reinforced sections as minimum, unless otherwise specified..

502.03 ADMIXTURES

Chemical admixtures used for water reduction and retarding purposes shall be of a type approved by the Engineer and shall conform to the requirements of Type A, Type D, Type F or Type G as specified in ASTM C494 (M). The Contractor shall be entirely responsible for the use of any approved chemical admixtures and they shall be used in strict accordance with the manufacturers' instructions. Unless otherwise recommended by the manufacturer the admixture shall be satisfactorily dispersed within the water required for the batch prior to its introduction into the mixer. Preliminary tests of cube strength, and other tests including plant trials shall be carried out using the combination of aggregates, cements and admixtures proposed for use.

When changing the brand or type of cement further tests shall be carried out.

All admixture containers shall be clearly labelled showing the manufacturer's name, the date of manufacture, the expiry date and the type of admixture per ASTM C494.

502.04 WATER-CEMENT RATIO

The quantity of water used in mixing shall be approved by the Engineer on the basis of preliminary tests and trial mixes and shall be the least amount that will produce a workable homogeneous plastic mixture which can be worked into the forms and around the reinforcement. In no circumstances shall the consistency of the concrete be such as to permit a separation of the aggregate from the mortar during handling. Excess water shall not be permitted and any batch containing such excess will be rejected.

In measuring water for each batch of concrete, allowance shall be made for the water contained in the aggregates and for the fluid content of any admixture as well as ice used for cooling the concrete mix. The total water in the batch shall be deemed to consist of the water carried by the aggregates and any admixtures plus the water and ice added.

Frequent tests including the slump test shall be carried out to ensure that a consistent water content is maintained.

The Concrete shall not bleed nor suffer plastic settlement.

The maximum water-cement ratio shall be the lower of the values listed in Table 502.01 for the concrete classes and the following values for the exposure:

i. 0.45 for concrete required to have low water permeability.

ii. 0.40 for corrosion protection of steel reinforcement in concrete exposed to chlorides from salt, saltwater, brackish water, seawater, or spray from these sources.

iii. 0.45 for concrete subject to moderate sulfate exposure.

iv. 0.42 for concrete subject to severe or very severe sulfate exposure

In no case shall the water-cement ratio exceed that given in Table 502.01 for each particular class of concrete.

502.05 SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM)

Add SCM to the mix as necessary to achieve the strength and durability requirements of the concrete classes with due account of the maximum water-cement materials ratios specified in Table 502.01 and the Clause 502.04 of these Specifications.

All the supplementary cementitious materials (SCM) have threshold values of addition below which significant durability or strength parameters do not develop. Nominal threshold addition values are as follows:

i. Silica fume (microsilica) 7% on (cement + silica fume)

ii. Ground granulated blast-furnace slag (GGBFS) 50% on (cement + GGBFS)

iii. Pulverized fly ash (PFA) 25% on (cement + PFA)

503 - MIX DESIGN

503.01 MIX DESIGN

Samples of all materials to be used in the mix shall be submitted to the Engineer for testing and such samples shall be tested in the Government laboratories as directed by the Engineer. No materials forming any part of this mix shall be delivered to the Site until the Contractor has received written approval to such material.

After receiving approval of the samples in writing from the Engineer, the Contractor shall submit in writing to the Engineer a proposed mix design proportioned by weight and based on trial mixes conducted with the approved materials to be used for each specified class of concrete for the project. Each mix design submitted shall be accompanied by all relevant data including details of the proposed method of placement.

No concrete works will be allowed to commence before the Contractor receives approval in writing from the Engineer for his mix design.

The Contractor must make arrangements for all the foregoing as early as possible and no claims for delay or compensation will be considered on account of waiting for the Engineer's written approval.

Should a previously approved mix design become unsatisfactory for any reason, in the opinion of the Engineer, the Contractor shall submit a revised mix design for approval by the Engineer as previously described. All expenses incurred on account of the implementation of a new mix design, or delays incurred as a result of such changes being required, shall be entirely the responsibility of the Contractor and no claim for delay or compensation will be considered. During the currency of the Contract, the Engineer will take samples of work mix at any time in order to check their conformity to the approved mix design.

All the foregoing shall be at the expense of the Contractor, but shall in no way relieve him of any of his responsibilities under the Contract.

504 - METHOD OF CONSTRUCTION FOR REINFORCED CONCRETE

504.01 FORMWORK AND FALSEWORK

504.01.1 Design

All formwork shall be designed and detailed by the Contractor who shall submit drawings to the Engineer for approval early enough to permit checking before erection of the forms.

If retarding admixtures are to be employed their effect should be duly considered during the calculation of the lateral pressures of the fresh concrete. Besides the weight of the formwork and freshly placed concrete the design loads shall include the weight of workmen, equipment, runways and impact, which together should be taken as not less than 250 kg/m2 of horizontal projection. Braces and shoring for formwork shall be designed to resist all foreseeable lateral loads plus a lateral load equal to 3% of the total vertical load. Falsework shall be designed in accordance with the requirements of AASHTO LRFD, except that a horizontal force equivalent to 1% of the vertical loads shall be applied in addition to those specified by AASHTO LRFD.

When prefabricated formwork shoring or scaffolding units are used the manufacturer's recommendations for allowable loads may be followed if supported by test reports or successful experience records. For materials which will experience substantial re-use, reduced values may be required.

The design of the formwork shall be the sole responsibility of the Contractor and the strutting and bracing of the formwork shall be such that there shall be no harmful deformation of the forms under the weight of the plastic concrete or due to methods adopted for the placing and compacting thereof or due to any incidental loading. No appliance for supporting the formwork or stagings shall be built into the permanent structure except with the Engineer's approval.

Formwork shall be designed for vertical loads and lateral pressures in accordance with ACI 347. In addition, the formwork shall be constructed to provide completed concrete surface complying with the tolerances specified therein.

The Contractor shall submit to the Engineer, for approval, eight (8) copies of shop drawings showing details of the falsework and forms intended to be used.

The shop drawings shall show the proposed details of construction such as sizes of members, spacing of bents, posts, studs, wales, stringers, collars, bolts, wedges, bracing, rate of pour, and the manufacturer's recommended safe working capacity of all form ties and column clamps. All assumptions, dimensions, material properties and other data used in making the structural analysis shall be noted on the drawing. Upon request, the Contractor shall furnish copies of the design calculations to the Engineer for examination as a condition of approval.

504.01.2 Types

All formwork shall be fabricated in accordance with one or other of the types specified hereunder.

A. Wrought Formwork

The surface shall be tooled or wrought and the formwork shall be constructed of steel or plywood (plastic faced or natural faced) or planed and dressed timber or undressed timber lined with an approved board. Plywood shall have a thickness of not less than 12 mm and waterproof glue shall have been used in its fabrication.

B. Lined Formwork

Formwork shall be made of sawed tongue and grooved timber boards, each of the same thickness and width. For visible outer surfaces of walls the boards shall be vertical.

C. Sawed Formwork

Formwork shall be of timber as sawed at the mill, Boards shall be of the same width. For visible outer surfaces of walls the boards shall be vertical.

504.01.3 Construction

The formwork shall be constructed accurately to represent the shape of the concrete as detailed on the Drawings. It shall be of suitable design and substantial construction and be approved by the Engineer. The Contractor shall make any necessary adjustment to allow for shrinkage, settlement or deflection which may occur during construction so that the finished concrete sections conform accurately to the specified dimensions true to line level and camber.

Wooden boards shall be fixed with such openings between the individual boards that they will close completely after the wetting which will precede the concreting.

All timber used in the formwork shall be sound well-sealed and free from loose knots and all formwork shall be constructed so that the joints fit tight enough to prevent the leakage of grout. Wrought formwork shall have a completely smooth face with tight joints. In all formwork for visible surface the pattern of the shutter joints shall be to the approval of the Engineer.

Should the Contractor elect to use metal forms they should preferably be of a type which does not require the use of ties that remain embedded in the concrete after the forms have been removed. Where ties are necessary, bolts and rods should be used, but they must be arranged so that when the forms are removed no metal shall be within 30 mm of any surface. Any holes or depressions remaining as a result of using the ties shall be plugged using an approved proprietary, pre-bagged, non-shrink, cementitious repair mortar, used in accordance with the manufacturer's instructions

Where holes are boxed out in the concrete for the subsequent installation of pipes, brackets, ragbolts or other ironwork or details the boxes shall become part of the formwork and shall be accurately set out and securely fixed. Should the Contractor elect to use other methods for building-in the above mentioned ironwork or details such methods shall be used only with the Engineer's prior approval but such approval shall in no way relieve the Contractor of his responsibility for the accuracy of the final finished positions of such ironwork and details to be built in.

Openings for the inspection of the inside of the formwork and for the escape of water used for washing out shall be formed so that they can be conveniently closed before placing of the concrete. All external corners shall in all cases be formed with 25 mm chamfers and splays unless the Drawings are specific as to their omission. The Contractor shall provide specially made forms for use as sides to joints.

Top shutters shall be provided for the upper surfaces of all slopes exceeding 15 degrees to the horizontal to enable the concrete to be properly placed. Provision must be made for the adequate vibration of the concrete in such shutters. Formwork shall be constructed so that the side shutters of members can be removed without disturbing the soffit shutters and, if the specification requires that certain props are left in place when the soffit shutters are removed, these props shall not be disturbed during the striking. The detailed arrangement for the props shall be submitted to the Engineer in advance of his approval.

The interior face of all formwork shall be carefully coated with an approved mould oil to prevent the adhesion of the concrete thereto. This preparation must not be allowed to come into contact with the reinforcement and no organic oil will be permitted to be used to coat the forms.

Before any concrete is placed, the formwork shall be cleaned of all sawdust, shavings, dirt, tiewire, nails, and other debris, it shall be washed out and finally all openings closed.

All formwork shall be inspected and approved by the Engineer before any concrete is placed in it but such approval shall not relieve the Contractor of his responsibility for the safety, accuracy and efficiency of the work.

As shown on the Drawings or where directed by the Engineer, concrete Class K180 will be used for blinding. It will be placed to a minimum depth of 75 mm or the depth shown on the Drawings, in the foundation of footings of structures to provide a working platform and to protect the stability of the foundation soils. The area shall be sufficient to provide support for formwork.

Forms for all surfaces which will not be completely enclosed or hidden below the permanent surface of the ground or for surfaces where plywood forms are not specified, shall be made of surfaced lumber or material which will provide a surface at least equally satisfactory. Any lumber or material which becomes warped or checked prior to placing of the concrete will be rejected.

Forms for all exposed surfaces not requiring concrete surface treatment shall be constructed of plywood or metal, at the option of the Contractor. The surface texture treatment shall be with form liners as specified herein under Finishing Concrete Surfaces.

All internal and external sharp edges and corners shall be chamfered to 25 mm by 25 mm. Triangular fillets or chamfer strips shall be made of plastic or shall be milled from clear, straight grain lumber and shall be surfaced on all sides. Curved surfaces shall be formed of plywood, metal or other suitable, approved material.

Form clamps or bolts shall be used to fasten forms.

Bolts or form clamps shall be positive in action and shall be of sufficient strength and number to prevent spreading of the forms. Lifting anchors may be installed in precast members. Bolts, form clamps and lifting anchors shall be of such type that they can be entirely removed or cut back 30 mm or more below the finished surface of the concrete leaving no metal within 30 mm of the concrete surface. Any holes or depressions remaining as a result of using the bolts, clamps etc. shall be plugged using an approved proprietary, pre-bagged, non-shrink, cementitious repair mortar, used in accordance with the manufacturer’s instructions All forms for the outside surfaces shall be constructed with stiff walers at right angles to the studs and all form clamps shall extend through and fasten such walers.

No concrete shall be deposited in the forms until all work connected with constructing the forms and placing all reinforcing steel, ducts, anchorages, or prestressing steel has been completed for the unit to be poured and the Engineer has inspected said form, reinforcing steel, ducts, anchorages, or prestressing steel.

If the concrete is to be prestressed, the falsework also shall be designed and constructed to support any increased or readjusted loads caused by the prestressing forces. Falsework or centering shall be founded upon a solid footing safe against undermining and protected from softening.

Openings shall be provided in forms to accommodate other work, including mechanical and electrical work. Support items required to be built into the forms shall be accurately placed and secured to avoid disturbance during concreting operations.

Drainage holes and weep holes shall be constructed as detailed on the Drawings. Forms for weep holes shall be as approved by the Engineer. No additional compensation will be allowed for this work.

504.01.4 Formwork, Embedded Articles

Sleeves, pipes or conduits of any non-reactive material located so as not to unduly impair the strength of the work may be embedded in the concrete with the approval of the Engineer.

Special care shall be taken to ensure that the article shall be securely fixed in the correct position and the Contractor shall at his own expense provide all necessary templates, temporary supports and other plant and labour required.

Items to be embedded in concrete shall be clean and free from oil or foreign matter that would weaken the bond of the concrete to these items.

The Contractor shall install in the formwork required inserts, anchors, expansion joint elements, sleeves, and other items shown on the Drawings or specified under other sections of these Specifications and shall co-ordinate installation with other trades in the proper location of such items. Ends of conduits, piping and sleeves embedded in concrete shall be closed with caps or plugs.

Tests on piping and other items which are required to be tested shall have been completed before starting concrete placement.

504.01.5 Removal of Formwork

The Engineer shall be informed in advance when the Contractor intends to strike any formwork and though the responsibility for the safe removal of the formwork rests with the Contractor the Engineer has the right to fix the time of striking if he decides this to be beneficial to the work.

The removal of formwork shall in all cases be supervised by an experienced foreman. All formwork shall be removed without such shock or vibration as would damage the concrete.

No separate payment shall be made to the Contractor for this work which will be deemed to be included in his rates for concrete.

Removal of forms and falsework shall not begin until the concrete has either obtained the percentage of the 28-day design strength shown below or until after the period shown below unless otherwise authorized by the Engineer.

Any work showing signs of damage through premature loading is to be removed and entirely reconstructed at the Contractor's expense.

Falsework Supporting	Period	Percentage Design Strength
Ramps, slabs or beams	7 days	80%
Walls	1 day	70%
Columns	2 days	70%
Sides of beams and all other vertical surfaces	1 day	70%

The percentage of design strength achieved shall be established by crushing cubes additional to those required for quality testing and which have been cured adjacent to and under the same conditions as, the works concrete.

For cast-in-place post tensioned bridge superstructures, falsework shall remain in place until all post tensioning has been completed.

Falsework under all bridge spans shall be completely released before concrete is placed for parapets, barriers and medians.

All formwork shall be removed from the cells of box girders.

To facilitate finishing, forms used for parapets, barriers, and exposed vertical surfaces shall be removed in not less than 24 hours nor more than 48 hours, depending on weather conditions.

504.01.6 Stay-In-Place Forms

When the use of stay-in-place forms is permitted in the Contract, precautions shall be taken to prevent voids in the deck slab. Particular attention shall be paid to proper vibration and consolidation of the concrete.

504.01.7 Inspection of Stay-In-Place Forms

When steel stay-in-place forms are used, one form panel per fifty meters of bay length shall be removed after the first deck slab pour and prior to any subsequent deck pours. The form panels to be removed will be chosen at random by the Engineer. The chosen panels shall be removed as soon as possible after the concrete has attained eighty percent of the design strength. The percentage of design strength achieved shall be established by crushing cubes additional to those required for quality testing and which have been cured adjacent to and under the same conditions as, the works concrete. The removal shall be done by experienced workmen without shock or vibration which might damage the concrete. The concrete surface thus exposed shall be inspected for voids and honeycomb or other signs of improper concrete placement. Evidence of improper placement may warrant removal of additional form panels, at the discretion of the Engineer, and measures shall be taken to correct the concrete placement procedures. Any voids or honeycomb shall be repaired, or the concrete replaced, as directed by the Engineer. Exposed form edges adjacent to the removed panels shall be free of ragged or unsightly edges. On subsequent deck pours the extent of form panel removal may be reduced, or form panel removal may be eliminated entirely, at the discretion of the Engineer.

The Contractor shall “sound” all stay-in-place forms after concrete placement by tapping the forms with a light hammer in order to detect any voids. Voids will be assumed if a hollow or dull sound is obtained when the forms are tapped. To distinguish between detrimental voids in the concrete and moulded-in voids in certain types of form panels, the Contractor shall keep records detailing the location of all such moulded-in voids.

Sounding shall be performed in the presence of the Engineer. Any suspect areas discovered in this manner shall be exposed by the removal of as many form panels as deemed necessary by the Engineer to determine the extent of the void or honeycombed area. The removal of these forms shall be in addition to the random removal specified herein. Repairs shall be made as directed by the Engineer. In the case of forms of any materials that become an integral part of the deck due to bonding, repairs shall be made by removing only that portion of the form within the limits of the void.

504.01.8 Measurement and Payment

No separate payment shall be made for formwork and falsework (including stay-in-place forms) which will be deemed to be included in the Bills of Quantities rates for the various items of Concrete Work.

504.02 STEEL FOR REINFORCED CONCRETE

504.02.1 Drawings, Bending Diagrams and Bar Lists

Before ordering reinforcing steel the Contractor shall furnish detailed working drawings, bending schedules for the approval of the Engineer. Where appropriate the Contractor shall designate the Contract Drawings as his working drawings and submit these together with such other drawings as are necessary to expand the detailing required for accurate production of schedules and fixing of the reinforcement. Unless otherwise agreed with the Engineer, the Contractor shall adopt the same bar references in his bending schedules as indicated on the Contract Drawings, if such are provided. Bending schedules shall show the weight of each bar, the total weight of each bar size, and the total weight of bars on the list.

The approval of working drawings, bar lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such working drawings, lists and diagrams. Any expense incidental to the provision of material furnished in accordance with such working drawings, lists and diagrams to make it comply with the Design Drawings shall be borne by the Contractor.

504.02.2 Samples

Before ordering reinforcing steel the Contractor shall submit for the Engineer's approval samples for testing from all proposed sources along with manufacturer's certificates indicating compliance with the Specifications. Source approval must be granted by the Engineer prior to ordering material and site delivery. Following source approval and delivery to site, representative samples of all reinforcing steel that the Contractor proposes to use in the works must be sampled, tested and approved by the Engineer in writing before work is commenced. In addition the manufacturer's certificates for each delivery shall be provided to the Engineer stating clearly for each bar size the place of manufacture, date and size of deliveries to Site, and all relevant details of composition, manufacture, strengths and other qualities of the steel, and indicating compliance with other parts of this Clause 504.02 of these Specifications.

Should a steel sample under test fail to meet the Specification requirements at any time or the Engineer considers that samples were not truly representative, or if it becomes apparent that reinforcing steel which has not been approved has been used on the Works, then the Engineer may instruct the Contractor to break out and remove completely all such sections of the work already constructed using such suspect reinforcing steel at no cost to the Employer.

504.02.3 Storage and Protection of Materials

Reinforcing steel shall be protected at all times from damage by storing on blocking, racks, or platforms, away from contact with the ground. The stored steel shall be covered to prevent contamination by dust which may contain detrimental salts. Prior to placing concrete, reinforcing steel which is to be embedded, shall be free from heavy rust, dirt, mud, loose scale, paint, oil, or any foreign substance.

504.02.4 Bending

All reinforcing steel shall be bent to the radius as given in ACI-315 unless otherwise noted on the Drawings.

504.02.5 Placing and Fixing of Reinforcing Steel

A. <u>General</u>

The reinforcing steel shall be assembled to the shapes and dimensions as shown on the Drawings. The bars shall be of the diameters indicated and shall be fixed rigidly and accurately in the forms in the positions shown on the Drawings. The bars shall be firmly bound together at intersections of bars to ensure that the reinforcement framework as a whole will retain its shape and the framework shall be so temporarily supported as to retain its correct position in the moulds during the process of depositing and consolidating the concrete.

The ends of all tying wires shall be turned into the main body of the concrete and not allowed to project towards the surface.

Spacing blocks approved by the Engineer shall be used to ensure accurate cover to the reinforcement where necessary, and these blocks shall be of precast concrete of strength at least equal to that of the concrete being placed. They shall be as small as practicable and shall be securely fixed in position by means of stainless steel wires cast into them. They shall be soaked with water immediately prior to concreting in. Alternatively, subject to the Engineer's approval of the type of spacer and its location within the structure, proprietary solid plastic or plastic coated steel spacers or chairs of appropriate size may be used to provide cover to the reinforcing steel. Plastic spacers shall be securely fixed by tie wire.

Bundle bars shall be tied together at not more than 1.80 metre centers.

Metal clips or supports shall not be placed in contact with forms or form liners.

No temporary supports to the reinforcing steel will be allowed to be incorporated in the finished concrete.

At the time of concreting all reinforcing steel shall have been thoroughly cleaned and freed from all loose rust, scale, mud, oil or any other coatings that might destroy or reduce the bond or induce corrosion and it shall also have been cleaned of all set or partially set concrete which may have been deposited thereon during the placing of a previous lift of concrete. Following cleaning, and immediately before concreting, the reinforcement shall be washed with potable water.

The placing of all reinforcing steel will be checked by the Engineer and in no case is concrete to be placed around any reinforcing steel that has not been approved by the Engineer. The insertion of bars into or the removal of bars from concrete already placed will not be permitted. Reinforcing steel temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer.

B. Bridge Decks

In bridge decks, reinforcing steel shall be fastened at alternate intersections unless this results in ties being more than 300 mm apart in which case each intersection shall be tied. The supports for reinforcing steel shall not be spaced more than 1.20 metres apart transversely or longitudinally. The placement of deck reinforcing steel shall not deviate more than 6 mm in the vertical direction, from the position shown on the Drawings. Concrete shall not be placed in any member until reinforcing steel placement has been approved by the Engineer.

C. Splicing

Except where shown on the Drawings, or approved shop drawings splicing will not be permitted without the approval of the Engineer.

Lap lengths shall be as shown on the Drawings or at 12 meter centers and shall conform to the requirements of the AASHTO LRFD Bridge Construction Specifications.

Welding of reinforcing steel will not be permitted unless shown on the Drawings or authorized in writing by the Engineer. All welds shall conform to the requirements of AASHTO LRFD Bridge Construction Specifications.

Dowels shall project a minimum of 40 bar diameters unless otherwise shown on the Drawings.

Metal supports which extend to the surface shall not be used. Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted.

Main reinforcing steel carrying determinate stresses shall be spliced only where shown on the Drawings or on approved shop drawings.

Bar couplers will be permitted, subject to the written approval of details by the Engineer. Couplers shall be capable of developing the yield strength of bars jointed, and, where appropriate, shall be of a type which will permit the splice to be made without the need to turn the bar. Concrete cover to the couplers shall be not less than that specified for the reinforcing steel.

504.02.6 Cover, Bar Sizes and Spacing

The cover to reinforcing steel, general limits on bar sizes and spacing of bars shall comply with the requirements of AASHTO LRFD Bridge Construction Specifications as modified herein or where specifically noted otherwise on the Drawings.

Concrete cover to reinforcement shall be as indicated on Drawings but shall not be less than the following:

i.	Concrete exposed to salt water and splash zone	100 mm
ii.	Concrete of all substructure elements cast against earth	100 mm
iii.	Concrete of all substructure elements exposed to weather	75 mm
iv.	Approach slabs	60 mm
v.	Superstructure cast-in-situ concrete exposed to weather	60 mm
vi.	interior faces of superstructure cast-in-place concrete except slabs	40 mm
vii.	Cast-in-situ slabs	30 mm
viii.	Precast superstructure elements, exposed surfaces	40 mm
ix.	Precast superstructure elements, interior faces	30 mm
x.	Precast parapets, concrete barriers, curbs, etc.	30 mm

Cover to reinforcement shall be checked before any concrete is cast. The bending of reinforcement at a cold joint is not permitted. Concrete cover shall be checked with a cover meter as soon as formwork is removed.

504.02.7 Substitution

Substitution of different size bars will be permitted only upon specific authorization by the Engineer and the substitute bars shall provide a steel area equal or larger than that called for by the design. No additional compensation will be allowed because of the substitution of larger areas of steel.

Millimetre Bar	Area Cm^2	Number Bar	Area Cm^2
10	0.79	No. 3	0.71
12	1.13		
13	1.33	No. 4	1.29
14	1.54		
16	2.01	No. 5	2.00
18	2.54		
19	2.84	No. 6	2.84
20	3.14		
22	3.80	No. 7	3.87
25	4.91	No. 8	5.10
28	6.16		
29	6.60	No. 9	6.45
30	7.07		
32	8.04	No. 10	8.19
36	10.18	No. 11	10.06

Table 504.02.7 – Reinforcing Steel Bar Conversion Table

For the indicated number bars in Table 504.02.7 a direct substitution may be made for the millimeter bar sizes shown at the required spacing as shown on the Drawings. Substitution of number bars not equivalent in area (to mm bars) shall be the closest number bar in area with spacing adjusted to provide the same areas per unit spacing. Substitution of millimeter, bars for mm bar sizes not readily available from the Contractor's source may be made on the same basis. All bar substitutions shall be approved by the Engineer in writing.

504.03 MIXING AND PLACING OF CONCRETE

504.03.1 Continuity of Concrete Work

The Contractor must have available sufficient quantities of approved materials, a batching plant of sufficient capacity and an adequate amount of hauling, placement and compaction equipment to ensure completion of any concreting operation in an efficient continuous operation. The Contractor shall provide sufficient equipment in reserve in case of breakdown.

The equipment available (as appropriate for the work in hand) must be approved by the Engineer prior to the start of concreting operations. It shall be the Contractor's responsibility to ensure that the Engineer's approval is sought and gained.

In the event of equipment breakdown or other unforeseen or unavoidable occurrence which causes, in the opinion of the Engineer, unacceptable delay in the concrete placement, a construction joint shall be constructed. The Engineer will designate if the joint is to be plain, bonded, or if it is to be a disbonded joint. No additional payment shall be made for such joints.

504.03.2 Batching and Mixing

A. <u>Location of Plants</u>

The location of the batching plants shall be agreed with the Engineer and the Contractor must submit to the Engineer for approval before erection of any batching or mixing plant his proposed arrangements for the storing or aggregates and the batching and mixing of the concrete. He must also submit details of the type or types of mixers and machines to be used, and his proposals for conveying the mixed concrete from the mixer to the points of deposition.

The Contractor must obtain the approval of Kuwait Municipality for the location of the batching plant.

B. Batching

i. General

Measuring and batching of materials shall be done in a batching plant.

Concrete shall be batched by weight and the weigh-batching machines used shall be of a type approved by the Engineer and shall be kept accurate and in good condition while in use on the works. Checks are to be made as required by the Engineer to determine that the weighing devices are registering correctly. Each mixer shall be fitted with a water measuring device having an accuracy within 1.0% of the quantity of water required for the batch and the measuring device shall be such that its accuracy is not affected by variations in the water supply pressure.

ii. Portland Cement

Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used to a batch of concrete unless the cement is weighed.

All bulk cement shall be weighed on an approved weighing device. The bulk cement hopper shall be properly sealed and vented to preclude dust emission during operation. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will not lodge in it nor leak from it.

The accuracy of batching shall be within plus or minus 1.0% of the required weight.

iii. Water

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not over 1%.

Arrangements for the cooling of the mixing water shall be to the approval of the Engineer as will the handling of admixtures.

iv. Aggregates

Stockpiling of aggregates shall be in accordance with Clause 301.03 of Section 3 (Sub-Base and Base Courses) of these Specifications. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. In case the aggregates contain high or non-uniform moisture content, a storage or stockpile period in excess of 12 hours may be required by the Engineer.

Batching shall be so conducted as to result in a 2% maximum tolerance for total weight of the required materials.

v. Bins and Scales

The batching plant shall include separate bins for the bulk cement, fine aggregate and for each size of coarse aggregate, a weighing hopper, and scales capable of determining accurately the weight of each component of the batch.

Scales shall be accurate to 1.0% throughout the range of use.

vi. Admixtures

Admixtures may be measured either by volume or by weight. The accuracy of measuring the admixture shall be within a range of error of not over 1%.

Independent equipment shall be used for measuring and adding each admixture to the mix. The dispenser shall contain a sight glass and an automatic mechanical cut-off device.

vii. Supplementary Cementitious Materials (SCM)

The upper limiting addition percentage values (maximum values) for each supplementary cementitious material shall be as follows:

Silica fume	10%	For all exposures
GGBFS	55%	For permanent dry (RH ≤ 50%) or damp (RH ≥ 85%)
GGBFS	70%	For concrete buried in permanently wet conditions
PFA	30%	For underground damp exposure (RH ≥ 85%)
PFA	45%	For concrete buried in permanently wet conditions

Where RH is the relative humidity.

When mixtures of supplementary cementitious materials are designed into the same mix, calculations based on proportionate replacement based on the limiting values shown above shall be derived by the use of Equations 1 and 2.

The following equations shall be used for calculating the limiting partial proportions of each mineral additive in the mix design:

Where

x is the % of Silica fume incorporated
y is the % of GGBFS incorporated and
z is the % of PFA incorporated

For normal concrete (lines 1, 2 and 4 above)

$$\frac{x}{10}+\frac{y}{55}+\frac{z}{30}=1 \qquad \text{(Equation 1)}$$

For wet or dry situations (lines (1, 3 and 5 above)

$$\frac{x}{10}+\frac{y}{70}+\frac{z}{45}=1 \qquad \text{(Equation 2)}$$

C. Mixing

i. General

All concrete shall be machine mixed. Concrete may be mixed at the site of construction at a central point or by a combination of central point and truck mixing or by a combination of central point mixing and truck agitating.

Mixing shall be in accordance with the appropriate requirements of AASHTO M157 and as specified herein, except that in lieu of the Contractor providing an electronically activated revolution counter he may provide a mechanically actuated device as approved by the Engineer.

All mixing equipment shall be kept in good operational condition at all times.

ii. Mixers

The mixing plant shall be of the drum or paddle box type and shall be approved by the Engineer. Continuous mixers will not be permitted.

Mixers having a rated capacity of less than 0.5m3 shall not be used to batch structural concrete. Unless otherwise agreed by the Engineer the following procedure shall be adopted for mixing.

The batch shall be so charged into the mixer that a portion (approximately 10%) of the water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period.

Mixing time shall be measured from the time all materials, except water, are in the drum. Mixing time shall be not less than 60 seconds for mixers having a capacity of 1.5 m3 or less. For mixers having a capacity greater than 1.5m3, the mixing time shall be not less than 90 seconds.

If timing starts the instant the skip reaches its maximum raised position, 4 seconds shall be added to the specified mixing time.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted

to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to continue operations while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.

Any concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at his own expense.

The Concrete shall be mixed until a mixture of uniform colour and consistency is obtained.

The mixer shall be operated at the speed recommended by the manufacturer.

The amount of concrete mixed in any one batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enter the mixer. On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean water. Any deposits of old concrete in the mixer shall be cleaned out by rotating clean aggregate and water in the drum before any fresh concrete is mixed. The aggregate and water shall be discarded.

Concrete mixed as specified above shall not be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

The concrete shall be mixed only in the quantity required for immediate use, and concrete not in place within one hour from the time the ingredients were charged into the mixer, or concrete that has developed initial set, shall not be used.

Where approved by the Engineer, batched quantities of cement and aggregates may be transported from the batching plant to site and there mixed in a mobile or truck mixer. Where the cement and aggregates are combined or are in direct contract prior to mixing, batches will be rejected unless mixing takes place within 30 minutes of the combination or contact, and if placing is not complete within 90 minutes of the combination or contact.

504.03.3 Delivery

Delivery of concrete shall be in accordance with the appropriate requirements of AASHTO M157 and as specified herein.

Immediately after mixing, the concrete shall be transported to the location of placing by methods which will prevent the separation, loss of contamination of any of the ingredients. Any method involving the use of pipes or chutes for transporting concrete will not be permitted, except with the written approval of the Engineer.

Transport of concrete from the mixers must be as rapid as possible and shall be so regulated that concrete placing is at a continuous rate unless delayed by the placing operations. Delivery shall be such that the interval between placing and compacting of batches shall not be so great as to allow the concrete in place to harden partially, and in no case shall such an interval exceed 30 minutes.

504.03.4 Hot Weather Concreting

When hot weather conditions exist that would impair quality and strength of concrete, place concrete complying with ACI 305 and as specified

Cool ingredients before mixing to maintain concrete temperature at time of placement to below 25 degrees C. Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water.

Concrete temperature shall not exceed 32 degree C and the temperature differential shall not exceed 25 degree C.

No concreting operation shall be carried out at ambient temperature of 40 deg. C or more.

For bridge decks that are located over or adjacent to salt water the maximum temperature of the concrete at time of placement shall be 27 deg C.

Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.

Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without puddles or dry areas.

Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, as acceptable to the Engineer.

Shade mixing plant and trucks, aggregates, water tank, and cement silo.

Paint the mixing plant, trucks, water tank, and cement silo with white or reflective paint.

Insulate the water tank and supply piping

Protect concrete during pouring, and formwork, from direct sunlight by use of shades and keep shades in position for 7 days from time of pouring.

Concrete placing shall be completed as quickly as possible to reduce transit time.

Curing of exposed concrete shall be immediately carried out.

504.03.5 Concrete Consistency

The slump test, measured in accordance with AASHTO T119 shall be used as a check on the consistency of the concrete. The slump shall be no higher than necessary for proper placement and compaction and shall not vary by more than 40mm from the slump agreed by the Engineer and the Contractor as being the accepted design slump for each particular approved mix.

504.03.6 Placing

A. General

Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Engineer.

All formwork must be thoroughly cleaned of all dirt, shavings, loose stones, sand, tie-wire etc. and all woodwork which will be in contact with the concrete shall be well soaked with water prior to commencing placing operations.

When the ambient temperature is 30^{o}C or higher, reinforcing steel shall be shaded for a minimum of 12 hours or kept cool by covering with wet hessian for a minimum period of 1 hour before the placing of concrete.

The method and sequence of placing concrete shall be as approved by the Engineer.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcing steel and under no circumstances shall concrete have a free fall of more than one metre. To convey the concrete as near as possible to its final position, drop cutes shall be used for small sections and bottom dump buckets or other suitable vessels for large sections. The concrete shall be placed so as to prevent water from collecting at the ends, corners, or along the faces of the forms, and it shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance in the form. All concrete shall be placed and compacted in even lifts with each batch adjoining the previous one.

The thickness of the lifts shall be between 150mm and 300mm for reinforced concrete and up to 450mm for unreinforced concrete, the thickness depending on the width of forms, the amount of reinforcing steel and the necessity of placing each lift before the previous one commences to set, all as approved by the Engineer.

The concrete shall be carefully and continually compacted and worked around the reinforcing steel without displacing the bars, and into the corners of the formwork so that it will be in close contact with the reinforcing steel and free from honeycombing.

After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcing steel.

Concreting in any one part or section of the work shall be carried out in one continuous operation and no interruption of the concreting work shall be allowed without the approval of the Engineer.

Where beams and slabs together form the integral part of the structure, they shall be poured in one operation, unless provision is made to form a construction joint on the Drawings or as approved by the Engineer.

Concrete in columns shall be placed in one continuous operation unless otherwise permitted by the Engineer. The concrete shall be allowed to set at least 12 hours before piercaps are placed, unless otherwise shown on the Drawings.

Workers shall not be permitted to walk over freshly placed concrete until it has hardened sufficiently to carry their weight without distortion and great care shall be taken to ensure that reinforcing steel projecting from concrete recently placed is not shaken or disturbed so as to destroy or damage the initial set of the concrete in contact with it.

B. Chutes and Associated Equipment

Chutes shall be of rubber or metal except that the use of aluminium chutes, tremies, troughs, and pipes will not be permitted.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. The water used for flushing shall be discharged clear of the concrete already in place.

Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement.

C. Pneumatic Placing

Pneumatic placing of concrete will be permitted if authorized by the Engineer. The equipment shall be so arranged that no vibrations result which might damage freshly placed concrete. Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 3 meters from the point of deposit. The discharge lines shall be horizontal or incline upwards from the machine.

D. Pumping

Placement of concrete by pumping will be permitted if authorized by the Engineer. The equipment shall be so arranged that no vibrations result which might damage freshly placed concrete. Where concrete is conveyed and placed by mechanically applied pressure the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

E. Compaction

The concrete shall be compacted with approved mechanical or electro-mechanical poker vibrators, of a type and size approved by the Engineer, operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction. Where approved by the Engineer, external formwork vibrators may be used in locations where it is impractible to use poker vibrators. The formwork vibrators shall be electrically or pneumatically powered and shall be fitted with individual on/off switches or valves. The use of formwork vibrators shall be carefully monitored so that the appropriate amount of compaction is imparted to the concrete without over or under-vibration. If formwork vibrators are used, the formwork shall be so designed and constructed to withstand the forces and vibrations applied.

Vibrators shall be capable of transmitting vibration to the concrete at frequencies of not less than 4500 impulses per minute (75 Hz) and visibly affecting a properly designed mixture with a 25 mm (1 inch) slump for a distance of at least 460 mm (18 inches) from the vibrator.

In all cases, not less than two vibrators in good operating condition shall be available at any site where concreting is taking place.

Over vibration shall be not allowed.

The poker vibrators shall have a diameter compatible with the spacing of the reinforcing steel and shall be properly handled by experienced personnel. They shall be immersed at regular intervals of approximately 10 times the diameter of the vibrator and to such a depth that the fresh concrete will be worked into previously placed. Care shall be taken not to displace the reinforcing steel nor to disturb or affect partially set concrete. Vibrators shall not be attached to the reinforcement in any circumstances. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually and vertically to ensure that no air pockets are formed.

All vibration compaction operations shall be completed immediately after the placing of concrete in its final position.

504.03.7 Protection of Placed Concrete

Freshly placed concrete shall be adequately protected from rain, dust storms, chemical attack and the harmful effects of sun, heat, wind, flowing water, vibrations and shocks. It shall also be fenced off or otherwise protected to prevent persons from walking thereon or articles being placed or thrown thereon. This protection shall continue until the concrete is sufficiently set such that it can no longer be damaged by these factors. The Engineer shall determine when the protection is no longer required but in any case this shall not be less than 24 hours after the time of placing.

504.04 JOINTS IN CONCRETE WORK

504.04.1 Construction Joint

Construction joints shall be in accordance with AASHTO LRFD Bridge Construction Specifications sub-section 8.8 as complemented herein.

Construction joints shall be made only at locations shown on the Drawings, as specified herein or approved by the Engineer.

Construction joints in abutment walls, wingwalls, and barrels of box culverts shall be placed at intervals not exceeding 9 metres except as otherwise shown on the Drawings or approved by the Engineer.

The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation. Shear keys, formed into or out from the surface of the previously placed concrete, or steel dowels shall be used where required. Shear keys formed into the concrete shall be formed by the insertion and subsequent removal of bevelled wood strips which shall be thoroughly saturated with water prior to insertion. Steel dowels may, at the discretion of the Engineer, be used in lieu of keys. The size and spacing of the keys and dowels shall be as approved by the Engineer.

Care shall be exercised not to injure the concrete or break the concrete-steel bond at any time. In constructing bridge floors where longitudinal joints are specified, a platform shall be constructed outside the longitudinal joints and supported on the lower slab form and workmen shall not be permitted to stand or walk on the projecting reinforcement bars until the concrete has hardened.

A. <u>Bonded Construction Joints</u>

Except where otherwise specified, bonded construction joints where required shall be made using any of the following procedures:

i. Plain Bonded Joint

After the concrete has hardened so that the header board or form can be removed without damage to the concrete, it shall be removed and the cement paste removed from the surface by washing with water under pressure or by sandblasting to expose clean, well-bonded aggregate.

To facilitate the removal of the cement paste, the surface of the header board or form that shall be in contact with the first pour may be thoroughly covered with a retarder. The retarder shall be a ready-to-use liquid compound that delays the set of the surface concrete to facilitate the exposure of the aggregate and shall be approved by the Engineer in advance of the beginning of the work. It shall produce results satisfactory to the Engineer and shall be evaluated on the basis of the manufacturer’s data and recommendations. When the

retarder is used, washing with water under pressure shall be used to expose clean, well-bonded aggregate. After the surface has been prepared, the concrete shall be kept saturated with water for a minimum period of 4 hours before placing the new concrete. The surface shall be free of standing water when the new concrete is placed.

ii. Epoxy Resin Bonded Join

After the header board or form is removed and the concrete has cured for the normal period, the second pour will be bonded to the first pour by the application of a two-component epoxy resin concrete adhesive to the concrete joint surface. Unless otherwise shown on the Drawings, the epoxy concrete adhesive shall conform to the requirements of ASTM C881 – 'Standard Specification for Epoxy-Resin-Base Bonding System for Concrete', Type V adhesive.

The surface on which the adhesive is to be applied shall be free of oil, dirt, and loose concrete. All unsound concrete should be removed until a base of strong, undamaged concrete is exposed on which to apply the adhesive. Heavy deposits of dirt or oil products shall be removed by wire brushing or sandblasting. The surface shall be free of moisture and dry before application of the adhesive. The adhesive shall not be applied to newly placed concrete before the normal curing period has elapsed. The material shall be used strictly in accordance with the manufacturer's instructions.

Because of toxicity of the materials, including the solvents, some safety and health hazards exist in the handling and use of the materials, and may cause serious rash in persons sensitive to the materials. Further, in the use of solvents as cleaning aids there exists a fire and flash hazard. The Contractor shall obtain from the formulator of the materials complete instructions as to the safety, health and handling precautions that must be exercised with respect to the materials to be used, and as to the procedure that shall be followed in the event that workmen come in contact with the material. Before they are permitted to proceed with the work, the workmen shall be instructed as to the hazards to which they will be exposed, the necessary safety precautions and the procedure to be followed in the event of accidental contact with the materials.

B. Construction Joints in Bridge Decks

Longitudinal and transverse bonded joints specified for bridge deck shall be constructed as specified in a, above, and as shown on the Drawings.

Horizontal bonded construction joints when specified between the top of the bridge deck and the kerbs or parapets shall be constructed as specified in a. above, and as shown on the Drawings.

The Contractor, subject to approval of the Engineer, may pour a bridge deck full width with horizontal bonded construction joints between the deck and kerbs or parapets. The omission of longitudinal bonded joints will not be permitted if the Contractor does not have the necessary equipment or capacity for a satisfactory job.

C. Unbonded Construction Joints

Unbonded construction joints shall be made by forming or striking off the previously placed concrete to a true and even surface and allowing it to set. After the concrete has set, the new concrete shall be placed in contact with it and thoroughly compacted to secure a close contact between the old and new concrete at all points, with no attempt to secure a bonding of the new to the old work.

504.04.2 Expansion Joints

Expansion joints shall be as specified in AASHTO LRFD Bridge Construction Specifications sub-section8.9, and as specified herein and in Section 13 (Bearings and Expansion and Fixed Joints) of these Specifications and as directed by the Engineer.

Unless otherwise shown on the Drawings, specified, or as otherwise directed by the Engineer, expansion joints shall be installed as noted herein:

a. For lined concrete drain (reinforced, and non-reinforced) walls, channels etc, expansion joints shall be installed at intervals not exceeding 10 meters nor closer than 3 meters.

b. For reinforced concrete culverts, retaining walls and similar structures, expansion joints shall be installed at intervals nor closer than 3 meters and not exceeding:

- 15 m for exposed culverts and walls
- 20m for drainage culverts
- 35 m for buried culverts and walls.

c. For median and side barriers of structures, expansion joints shall be installed at 6 meter centers.

d. For kerbs and paved areas of precast or in situ concrete, expansion joints shall be installed at intervals not exceeding 10 meters nor closer than 3 meters.

Unless otherwise specified in the Contract Documents, expansion joints shall comprise a 20 mm thickness of preformed non-extruding joint filler sealed with a polysulphide sealant all as specified herein.

With the approval of the Engineer, expansion joints may be adjusted in location to coincide with the Contractors intended construction joint locations.

504.04.3 Joint Fillers

Joint filers shall be as specified herein and shall be installed in the locations shown on the Drawings, as specified herein or as directed by the Engineer.

A. Sponge Rubber and Cork

Joint filler shall be a non-extruding and resilient non-bituminous preformed type conforming to the requirements of AASHTO M153. Type I – sponge rubber, Type II – cork, or Type III – self-expanding cork, as approved by the Engineer.

B. Expanded Polyethylene

Joint filler shall be compressible closed cell foam sections or sheet. The load required to compress a test specimen to 50% of its thickness before test shall not be less than 0.12 N/mm2 nor greater than 0.20 N/mm2. Water absorption after six weeks total immersion shall not exceed 4% by volume.

C. Bituminous Impregnated Fibre Board

Joint filler shall comply with the requirements of AASHTO M213/ASTM D1751.

The joint filler shall be cut to the same shape as that of the surfaces being jointed, less an allowance for any specified sealant. It shall be firmly fixed against the surface of the concrete already in place in such a manner that it will not be displaced when concrete is placed against it. Expanded polyethylene shall be bonded into position using an adhesive approved by the manufacturer. Immediately after form removal, the expansion joints shall be carefully inspected, and any concrete or mortar that has sealed across the joint shall be neatly cut and removed.

504.04.4 Sealants

Sealants shall be as specified herein and shall be utilized as shown on the Drawings or a directed by the Engineer.

A. Polysulphide Sealant

Polysulphide sealant shall be a two-component, cold curing polysulphide liquid polymer meeting Federal Specification TT-S-227, Class A, and shall be mechanically mixed. Application shall be in accordance with the manufacturer's instructions especially in regards to the use of primers and cleaning of the joints.

Where polysulphide sealants are to be used directly against an existing bituminous surface, a suitable bond-breaker such as polyethylene tape shall be used against the bituminous surface to avoid contact with the sealant.

Unless otherwise shown on the Drawings,,these sealants shall be used for joints in box culverts, median barriers, sewer works, etc.

Where bituminous materials are to be laid adjacent to a polysulphide seal, the polysulphide sealant shall first be allowed to cure completely, for a period of not less than two weeks, before the bituminous material is applied. In addition, a suitable bond-breaker such as polyethylene tape shall be applied to the sealant to

isolate it from the bitumen.

B. Elastomeric Sealants

These shall be two-component, cold poured sealants meeting the requirements of either BS 5212 or Federal Specification SS-S-200E.

Application shall be in accordance with the manufacturer's instructions especially in regards to primers and cleaning of the joint.

Unless otherwise shown on the Drawings, these sealants shall be used for joints in concrete pavements, slabs, etc.

C. Hot Poured Sealants

These shall be hot-poured meeting the requirements of either ASTM D3406 or BS 2499.

Application shall be in strict accordance with the manufacturer's instructions especially in regards to heating and reheating.

Unless otherwise shown on the Drawings, these sealants shall be used when jointing to asphalt pavement or other bitumen based materials.

504.04.5 Measurement and Payment

504.04.5.1 Method of Measurement and Basis of Payment

There shall be no separate measurement and payment for the furnishing and installation of joints in Concrete Work, the costs of which will be deemed to be included in the rates for the various concrete items in the Bills of Quantities.

504.05 CONCRETE FINISHING WORKS

504.05.1 Finishing Concrete Surfaces

Classes of Concrete Finishes

A. Class 1, Ordinary Surface Finish

Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or are not to be waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned, and after having been kept saturated with water for a period of not less than three hours shall be carefully pointed and trued with an approved proprietary pre-bagged, non-shrink, cementitious repair mortar, used in accordance with the manufacturer's instructions. Mortar used in pointing shall be cured as specified in Clause 504.06 of these Specifications. All expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

The resulting surfaces shall be true and uniform.

B. Class 2, Rubbed Finish

Surfaces to receive a Class 2 finish shall be treated as for a Class 1 Ordinary Surface Finish except after the minimum time has elapsed for the pointing work for the Class 1 finish to have thoroughly set the concrete shall be kept saturated with water for a minimum period of three hours. Surfaces shall then be rubbed with a medium carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time.

After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. The rubbing shall be continued until the entire surface is a smooth texture and uniform colour.

After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder and objectionable marks.

C. Class 3, Surface Texture Treatment

The Class 3 surface texture treatment shall be obtained by the use of form liners matching sample panels available for inspection at locations designated by the Engineer or as shown on the Drawings. Before ordering form liners, the Contractor shall submit samples of each form liner panel for selection and approval by the Engineer.

Form liner panels shall remain stable and free from distortion at temperatures up to 80^{o} C.

The form liners shall be set in the forms and used in accordance with the manufacturer's instructions. Care shall be taken when setting formwork to ensure that the depth of texture treatment is outside of the neat wall line providing the concrete cover to reinforcing steel as shown on the Drawings.

Irregularities of pattern and holes in the final textured surface shall be patched with cement mortar and all stains shall be removed to the satisfaction of the Engineer either by wire brushing or by sandblasting.

D. Class 4, Applied Surface Finish

1. General Requirements

Surfaces to receive a Class 4 Applied Surface Finish shall be prepared as specified for Class 1 finish, except where the surfaces are specified to receive a Class 3 finish.

The Applied Surface Finish shall be a coating specifically formulated for this type of application and shall meet the following requirements:

i. The protective coating shall comprise two elements: a penetrating primer and a water-based acrylic coating.
ii. The total dry film thickness of the protective coating system shall be not less than 400 microns

iii. The coating system shall provide a CO_2 diffusion resistance equivalent to not less than 120mm of 30 N/mm^2 cover or 40mm of air cover – (Taywood Method).

iv. The coating shall provide an adhesion greater than 1.0N/mm2

v. The coating shall provide a static crack accommodation not less than 2mm.

vi. The coating system shall provide a water vapour transmission resistance (SD) not more than 0.4 metres (Taywood method).

vii. The manufacturer of the coating shall supply evidence that the coating has performed satisfactorily for a minimum of 5 years in climatic conditions similar to those of Kuwait including similar standards of ultra violet light intensity.

viii. The finish colour shall be as approved by the Engineer.

ix. The surface preparation of the base concrete and the storage, mixing and application of the applied surface finish coatings, including application materials and equipment and the ambient conditions for application, shall be in strict conformance with the coating manufacturer's recommendations and/or instructions.

x. Applied Surface Finishes which require the on-site addition of thinners or which require on-site batching of component parts shall not be acceptable.

xi. A minimum of two coats of the applied surface finish will be required.

xii. The finish shall be applied at a time recommended by the coating manufacturer.

2. Colour and Texture

The required colour and, if applicable, texture of the coating shall be specified in the Contract Documents or

selected by the Engineer. The coating shall be selected by the Engineer on the basis of trial panels prepared by the Contractor.

The Contractor shall supply manufacturer's samples, specifications and chemical compositions of coatings meeting the requirements of these Specifications and which correspond to the colour and texture specified, selected and approved. A minimum of ten (10) samples shall be provided, of which not more than three (3) shall be from any one manufacturer. The Engineer shall select a maximum of five (5) coatings for which trial panels shall be constructed by the Contractor as specified herein.

3. Trial Panels

i) General

The Contractor shall construct trial panels for the coatings selected by the Engineer. The trial panels shall be constructed of the class of concrete to be used in the works. Where the same coating is to be applied to different classes of concrete, the class of concrete used for the trial panels shall be selected by the Engineer.

For all trial panels the concrete shall be mixed, cured, finished and the Applied Surface Finish coating applied in the same manner as that intended for the permanent works

ii) Construction

The panels shall be at least 2m X 2m X 300mm thick and shall be reinforced to permit handling without breakage. The trial panel finally accepted by the Engineer as the standard for the permanent works shall be stored by the Contractor in direct sunlight with one half of the panel masked, in a manner satisfactory to the Engineer, to prevent light reaching the coating. The masking shall be easy to remove and replace so that at any time the ageing of the coating may be assessed.

The concrete surface preparation and coating application procedure details for the approved trial panel shall be recorded and will provide the basis for the relevant permanent works.

Trial panels shall be tested for permeability and DIN 1048 as defined in Clause 507.03.02 of these Specifications as a check on the effectiveness of the primer. Acceptance of the coating shall be based on compliance with the following acceptance limits. Based on this result, the Engineer may reject the work or require additional coating.

- DIN 1048 results for coated surfaces: one fifth of the limits for the unprotected surfaces defined in Clause 507.03.02 of these Specifications.
- Rapid Chloride permeability test results for coated surfaces: charge passed should be less than 500 coulombs.

Trial panels shall be broken up and disposed of by the Contractor when instructed by the Engineer.

Trial panels as specified herein shall be prepared for each and every colour and texture of coating specified in the Contract Documents or selected/approved by the Engineer.

4. Application of Coating Requirements

i. Protection

The Contractor shall protect all areas and installations not receiving an Applied Surface Finish from splatter or other damage from the application of the Applied Surface Finish. Any areas damaged shall be repaired at the Contractor's expense and to the approval of the Engineer.

ii. Materials

The Applied Surface Finish materials shall be delivered in the manufacturer's sealed containers bearing the product and the manufacturer's name, the date of manufacture, the date of expiry, clolour and the manufacturer's batch or stock identification number.

iii. Coating Appearance

The finished coating shall be uniform in colour and texture, free from runs, drops, ridges, waves, laps, etc.,

and shall match the colour and texture of the approved sample panel to the Engineer's satisfaction.

Should the coating, in the Engineer's opinion, be non-uniform in colour and/or texture or should there be runs, drops, ridges, waves, laps etc in the coating, the Contractor shall propose remedial works for the Engineer's approval.

Should the Contractor's proposals be unacceptable, or should the remedial works result in an unsatisfactory finish the Engineer shall require the Contractor to:

a. Recoat the complete area affected or
b. Remove, to the extent possible, the coating from the affected area and re-apply the coating.

The Engineer shall notify the Contractor which option he requires and in the case of a re-coating being unsatisfactory the Engineer shall require the Contractor to remove, to the extent possible, the re-coating and the original coating and re-apply a new coating.

All re-coating works and removal and re-application of coatings shall be at the Contractor's expense.

If the colour of the coating as applied to the permanent works departs from that of the approved trial panel colour (as masked) to a degree which, in the opinion of the Engineer, is unacceptable, the Contractor shall stop application and shall demonstrate to the Engineer's satisfaction that the coating formulation and/or application method can be suitably adjusted to produce a colour matching that of the trial panel. If considered necessary by the Engineer the Contractor shall produce additional trail panel(s) at no cost to the Employer to demonstrate that a colour match can be obtained.

If, in the opinion of the Engineer, a satisfactory colour match cannot be obtained, the Engineer, at his option, may require the Contractor to remove, to the extent possible, the unacceptable coating applied to the permanent works and/or to apply an alternative coating. Such an alternative coating will be selected by the Engineer on the basis of the previously prepared trial panels except that where in the opinion of the Engineer such trial panels are unacceptable, the Contractor shall supply additional manufacturer's samples and trial panels as the Engineer may require until a coating satisfactory to the Engineer is obtained.

The cost of the removal of unsatisfactory coating and the costs of any trial panel for alternative coatings shall be borne by the Contractor.

5. Testing

Testing of the coating shall conform to the following:

- Carbon dioxide diffusion resistance (R value)	Taywood Laboratories
- Water vapor transmission	Taywood Laboratories
- Chloride ion diffusion	Taywood Laboratories
- Reduction in chloride ion penetration	BS 1881: Part 124
- Tear resistance	ASTM D624
- Crack Bridgeability	BRE method

E. <u>Class 5, Unformed Surface Finish</u>

Unformed Surface Finish to Class 5 Type 1 shall be uniformly levelled and screeded to produce a plain, textured or grooved surface as described on the Drawings or specified by the Engineer.

Unformed Surface Finish to Class 5 Type 2 shall be uniformly levelled and screeded and shall be finished smooth with a wood float.

F. <u>Class 6, Textured Finish for Asphalt Work</u>

Surfaces of concrete which are to receive an asphalt surfacing or similar shall have a Textured Finish formed by brushing with a stiff broom transversely after the initial set has taken place.

G. Class 7, Bridge Decks

Finishing for bridge decks not receiving an asphalt surfacing shall be as specified in Clause 508.02 of these Specifications.

504.05.2 Surfaces to Receive Finishes

Except as otherwise or additionally specified in the Contract Documents surfaces receiving finishes shall be as follows:

A. Class 1

All surfaces which will be buried or not exposed in the completed works and not specified to receive an alternative class of finish.

B. Class 2

All exposed surfaces not specified to receive an alternative finish.

Class 1 and 2 finishes shall be completed as soon as possible after removal of the forms, but in no case shall the time taken be in excess of 24 hours.

C. Class 3

i. The front faces of abutments from 600 mm below finished ground line or from the top of the barrier, where a barrier is formed along the face of the abutment, to the bearing seat, and including the exposed faces to cheek walls on both ends of the abutment seat.

ii. The exposed faces of retaining walls and wing walls from 600 mm below finished ground line or from the top of the barrier, where a barrier is formed along the face of the wall, to 100 mm below the joint line between the wall and the parapet or barrier cast on the top of the wall or, in the absence of a parapet or barrier, to the top of the wall.

D. Class 4

The exposed faces of piers, bridge (vehicular, pedestrian, utility) superstructures (excluding the trafficked surface), parapets, surfaces to receive Class 3 texture finish, and any other surfaces specified on the Drawings or in the Contract Documents.

The color and texture of the Applied Surface Finish shall be selected by the Engineer.

For piers, retaining walls, abutments and wing walls the Class 4 finish shall be carried to 300 mm below finished ground level.

504.05.3 Measurement and Payment

504.05.3.1 Method of Measurement and Basis of Payment

There shall be no separate measurement or payment for all Classes of finishes, the costs of which will be deemed included in the rates for the various concrete items in the Bills of Quantities.

There shall be no separate measurement or payment for trial/sample panels the costs of which shall be deemed to be included in the rates for the various concrete items in the Bills of Quantities.

504.05.4 Fixing of Ironwork

All brackets, rag-bolts and other metalwork for which holes have been boxed out or left in the concrete of a structure shall be carefully grouted in to their correct positions using an approved proprietary, pre-bagged, non-shrink, cementitious grout used in accordance with the manufacturer's instructions.

504.05.5 Reconstruction of Faulty Work

If, after removal of the formwork, any member or portion of the work should prove to be of inferior workmanship or to be in any way whatsoever defective, or should tests on samples taken from the work show

that the concrete used therein is of inferior quality, then, where instructed by the Engineer, such work shall be cut out and replaced at the Contractor's expense.

504.06 CURING

All new-placed concrete shall be cured, and curing shall begin immediately after removal of formwork and shall be continued throughout any finishing processes and for at least seven days. Curing shall be done so that moisture is always present, and shall be an integral part of the concreting operations. Improperly cured concrete will be considered defective, and the Engineer will stop all of the Contractor's placing operations until proper procedures are put into effect. Any concrete adversely affected by a lack of curing shall, where instructed by the Engineer, be cut out and replaced at the Contractor's expense.

When the air temperature is expected to fall below 2°C, the Contractor shall provide suitable measures to maintain the concrete surface temperature between 10°C and 32°C.

One of the following methods of curing, or a combination thereof, shall be used except that the Engineer may require method a. for curing exposed surfaces:

A. Supplying Additional Moisture

This method shall include supplying additional moisture by ponding, sprinkling, or fogging. Coverings such as hessian shall be used to retain water so supplied. The use of sawdust will not be allowed and coverings which cause unsightly discoloration of concrete shall not be used. Any method which results in the concrete being alternately wet and dry will be considered an improper curing procedure. Coverings shall be placed as soon as possible after finishing operations have been completed. The coverings shall be kept continuously moist.

B. Preventing Moisture Loss

This method shall consist of preventing moisture loss from the concrete. It may be done with the use of approved plastic sheets or spray-applied liquid membrane curing compound except where other requirements prohibit the use of these compounds. If a formed surface is to be rubbed, the concrete shall be kept moist before and during the rubbing, and the curing shall be initiated immediately following the first rub while the concrete surface is still moist. Bridge decks, approach slabs, sidewalks and kerbs shall be covered with wet hessian or approved equal as soon as the concrete is sufficiently set to support this material without damage to the finish. This moisture-retaining material shall then be saturated with water and the entire area covered with close-fitting plastic sheeting.

Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.

Membranes used to prevent moisture loss shall comply with the following:

i. Polyethylene Sheets

The sheets shall be the widest practicable width and adjacent sheets shall overlap a minimum of 150 mm and shall be tightly sealed with pressure sensitive tape, mastic, glue, or other approved methods to form a complete waterproof cover of the entire concrete surface. The sheeting shall be secured so that wind will not displace it or blow under the sheets in a 'tunnel' effect. If any portion of the sheets be torn or damaged before expiration of the curing period the torn or damaged portions shall be immediately repaired.

ii. Curing Compounds

Only Type 2 liquid membrane curing compounds conforming to ASTM C309, may be used when approved by the Engineer as the initial and final curing agents on structural concrete subject to the following limitations:

1. If the membrane film is broken or damaged at any time during the curing period, the area or areas shall be immediately recoated to the original requirements.

2. Curing compounds shall be spray-applied to unformed areas as soon as the water sheen has practically disappeared from the concrete, or immediately after the forms have been removed from surfaces not to be rubbed.

3. Curing compounds shall not be used on surfaces receiving a rubbed finish or waterproofing treatment or on surfaces which are to receive an asphaltic concrete pavement overlay. In such cases a curing compound may be used but it shall be subsequently completely removed by abrasive blasting to the approval of the Engineer prior to applying the required treatment or placing the pavement courses.

4. If there is to be any delay in applying curing compound, the surface shall receive moist curing until the compound can be applied.

5. Curing compound shall be applied with equipment which will produce a fine spray, and all compounds shall be thoroughly agitated just prior to use. Following initial application, the surface shall be sprayed again immediately at right angles to the first application. The rate of each application shall be in accordance with the manufacturer's recommendations, but not less than 1 litre for each 3.6m2 of surface. Care shall be taken to prevent application to joints where concrete bond is required to reinforcing steel and to joints where joint sealer is to be placed, unless the membrane is subsequently removed as in (3), above.

6. Curing compound shall be applied to bridge decks for initial supplemental curing. Type 2 or type I-D, Class B – lacquer based, compounds shall be used. The compound shall be applied immediately after finishing as soon as the initial surface sheen is disappearing from the concrete and should be followed as soon as possible by a wet cure method. The follow-up wet cure method shall be in accordance with Clause 504.06a of these Specifications. If deemed necessary by the Engineer prior to laying asphalt pavement on the deck the curing compound shall be thoroughly removed as in (3) above, except in the case of the type I-D, class B – lacquer based compound which can remain in place if shown to have good bonding qualities with bitumen products.

7. No separate payment shall be made for this work which will be deemed to be included in the rate for the various concrete items in the Bills of Quantities.

504.07 CONCRETE PROTECTION AGAINST AGGRESSIVE ENVIRONMENT

The groundwater and the soil in Kuwait are generally rich in sulphate due to the presence of gypsum and other minerals within the soil and will therefore be aggressive towards concrete. Thus it will be necessary to design buried concrete structures below or up to 1 meter above ground level to withstand sulfate and other chemical attack. The Contractor is given an option to select the concrete mix design and protection measures that are most economical as long as it is in compliance with the below.

In addition to concrete strength and other requirements listed in the Contract Documents, concrete mix has to be designed in accordance to the requirements of the British Research Establishment (BRE) Special Digest 1:2005 Concrete in Aggressive Ground. This guide is published in the UK by the Construction Research Communications, Limited.

The following minimum design parameters shall be used:

a. Design Chemical (DC) class of the soil DC-3;
b. DS class for the soil DS-4;
c. Aggressive Chemical Environment for Concrete (ACEC) = AC-4S;
d. Minimum design life to be 100 years.

The above parameters are minimum requirements. The Contractor shall verify for himself that they meet site requirements following the additional ground investigation subject to the approval of the Engineer.

The above requirements shall apply to all underground concrete structures including box culverts, manholes, access shafts, transition chambers and NDM crossings.

Concrete structures below seawater or in the splash zone shall be coated with epoxy paint subject to the Engineer's approval.

Exposed concrete surfaces in marine aggressive environment shall receive a Class 4 Applied Surface Finish as specified in Clause 504.05.1, d. of these Specifications as amended here in. The static crack accommodation of the coating shall be reduced to 0.6 mm.

504.08 MEASUREMENT AND PAYMENT FOR CONCRETE WORKS

504.08.1 Method of Measurement and Basis of Payment for Concrete

Measurement of plain and reinforced in-situ concrete shall be by the meter cube for each type, class, location in the structure (structural element) and finish measured overall and no deductions shall be made for the following:

a. Volume of reinforcing steel or other items embedded in the concrete.
b. Holes, pockets, sockets, mortices and the like less than 0.2 m^3 in volume.
c. Holes introduced, with the consent of the Engineer, by the Contractor for the convenience of transportation, erection or construction irrespective of the size of the holes and whether or not the holes are made good.

Additional concrete placed, with the consent of the Engineer, by the Contractor solely for the purpose of facilitating his work shall not be measured for payment.

Measurement of blinding concrete shall be by the meter cube. The volume of blinding concrete to be paid for will be measured between the limits shown on the Drawings except that no concrete beyond a limit of 500 mm outside the lines of the footings of structures shall be included in the measurement for payment.

Where Bills of Quantities items have the phrase “including concrete” then the volume of concrete used in these items is deemed to be included in the rate for such items and will not be measured separately.

Payment for concrete shall be at the rate inserted in the Bills of Quantities which rate shall include for:

- Cement and other cementitious materials, aggregates, water and admixtures including their testing, storage, handling and transportation.
- Washing of aggregates, if required.
- Ice, if required, added in the mix water.
- Plant, machinery and equipment required for the production of concrete.
- Design of mixes, taking samples and testing.
- Transportation and delivery of concrete to work areas.
- Placing, compacting, vibrating and finishing of concrete.
- All formwork irrespective of the material used and the quality of surface finish specified and removal of the formwork.
- All falsework supporting and stabilising formwork.
- Curing of concrete, testing samples and test panels.
- Tooling, if required, to achieve the specified surface finish.
- Corrective measures and the means of carrying them out required in the event of the concrete being not in accordance with the Drawings and/or Specifications.
- Handling, transportation and erection of precast concrete members.
- Grout and/or epoxy used in precast construction including material and equipment for temporary prestress, if required.
- Material, plant and equipment associated with particular methods of construction.
- Joint fillers, joint sealants, weep holes, waterstops, dowel bars and other accessories as shown on the Drawings including material, plant handling, transportation testing, storage, workmanship and associated ancillaries.
- Surface finish.
- All labor, materials and equipment.

Forming or drilling holes, forming or cutting pockets, mortices and the like, furnishing and placing grout, furnishing and placing joint filler and sealer, tie bars, dowels, grout tubes, waterstops, weepholes and the like shall be considered as incidental to the price paid for concrete work and no additional compensation will be allowed.

No separate payment shall be made for surface finish including surface additives and hardeners, to concrete which shall be deemed to be incidental to the work and to have been included in full in the rates for the work.

504.08.2 Method of Measurement and Basis of Payment for Reinforcing Steel

Each particular grade of reinforcing steel bar incorporated in the concrete shall be measured in kilograms based on the total computed weight for the sizes and lengths of bars, as shown on the Drawings or authorized by the Engineer.

For computing the weight of reinforcing steel bars for payment, the theoretical weights given in Table 504.08.1 shall be used:

Bar Dia. Mm	Weight kg/m	Bar Dia. mm	Weight kg/m	Bar Dia. mm	Weight kg/m
4	0.100	16	1.580	28	4.830
5	0.154	17	1.768	29	5.146
6	0.222	18	2.000	30	5.550
7	0.302	19	2.209	31	5.830
8	0.395	20	2.470	32	6.310
9	0.496	21	2.700	33	6.664
10	0.617	22	2.980	34	7.130
11	0.740	23	3.257	35	7.496
12	0.888	24	3.550	36	7.990
13	1.034	25	3.850	40	9.870
14	1.210	26	4.170	44	11.980
15	1.377	27	4.461	48	14.270

Table 504.08.1 – Measurement and Payment for Reinforcing Steel

The weight of reinforcing steel bars used in parapet walls and median and side barriers on structures shall be measured and paid for under this Clause.

Where Bills of Quantities items have the phrase “including reinforcement” then the payment for reinforcing steel used in these items is deemed to be included in the rate for such items and is not measured separately.

No allowance will be made for spacers, clips, wire, separators, wire-chairs, chairs, standees and other material used in fastening the reinforcing steel in place. If bars are substituted upon the Contractor’s request and as a result more steel is used than specified, only the amount specified shall be included.

No separate measurement is made for bars of different diameters. The unit rates in the Bills of Quantities shall be deemed to cover all diameters.

For long bars the measurement will allow one lap at 10 metre centres unless the position of the lap is shown differently on the Drawings. Measurement of splices or laps in reinforcement not shown on the Drawings will not be made.

Fabric mesh reinforcement is measured separately by weight based on the theoretical quantity of metric tonnes complete in place as shown on the Drawings or placed as ordered by the Engineer. No separate measurement is made for different mesh sizes or different wire diameters. For standard fabric, the weight will be based on the mass in kg/sq.m. listed in Table A.1 of BS 4483.

The quantity of steel reinforcing bars and fabric mesh reinforcement shall be calculated to the nearest three decimal places.

The accepted quantities of reinforcing steel (bar and mesh), determined as provided above, shall be paid for at the rates included in the Bills of Quantities, which rates shall be full compensation for supplying, fabricating, transporting, delivering, erecting and fixing, materials, all labour, materials, equipment, tools and incidentals required for proper installation and completion of the work.

504.08.3 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
504.1	Concrete (class) (type), (location in structure) and (finish)	cu.m.
504.2	Mild steel bar reinforcement of any diameter	t.

504.3	High tensile steel bar reinforcement of any diameter (grade)	t.
504.4	Fabric wire mesh reinforcement of any size	t.

505 - PRECAST CONCRETE

505.01 GENERAL

505.01.1 Requirements

This Clause covers the requirements for ordinary precast concrete works. The class of concrete for each application is to be as specified herein or as shown on the Drawings.

All Clauses referring to cast in situ concrete shall apply to precast concrete and, in addition, the Contractor shall satisfy the Engineer that the precast concrete units are not moved or loaded until they have attained the requisite strength.

505.01.2 Transport, Storage and Erection

Units shall be so stored, transported and fixed that they will not be overstressed at any time or suffer any damage.

Precast units shall be adequately braced and supported during erection to ensure proper alignment and safety.

The lifting methods for all precast members shall be to the approval of the Engineer and the Contractor shall submit details of any hook or lifting eyes he proposes to cast into the members. Such details shall include proposals for cutting the eyes or hooks from the precast members and for restoring the surface.

505.01.3 Finish

On removal from the moulds the precast concrete units shall be examined and all surfaces that will be permanently visible shall have a smooth and dense finish of uniform texture free from holes, fins and shutter staining. Any precast concrete unit which is found to be defective in any respect shall be rejected.

505.02 KERBSTONES

505.02.1 Kerbstones Sampling and Testing

Sampling and testing of kerbstones shall be in accordance with BSI BS EN 1339-2003, 1340-2003.

505.02.2 Raised, Transitional and Edge Kerbstones: Foundation, Haunching and Joints

The foundations to kerbstones shall be cast in situ unreinforced concrete class K180, using Type V cement, to the dimensions shown on the Drawings. The gradation of aggregate used for this purpose shall be 37.5 mm to 3.2 mm. The Contractor shall make the necessary formwork on both sides and shall support it with vertical and horizontal props as per the required levels and setting out. The Contractor shall not be allowed to commence casting before obtaining the approval of the Engineer in respect of the formwork, and casting shall be carried out in length not exceeding ten metre runs separated by expansion joints. Where shown on the Drawings, the kerb foundations shall be cast on a layer of 1000 gauge polyethylene sheet and, where shown, shall incorporate vertical dowel bars in accordance with the details provided. After soaking both kerbs and foundations with water, kerbstones shall be constructed on the foundation with cement and sand (1:2) mortar, providing that the thickness of the mortar layer shall not exceed 30 mm unless otherwise shown on the Drawings. The vertical joints between the kerbstones shall be filled with the same mortar, pointed and cleaned with Hessian. After a lapse of at least 5 days, the Contractor shall make the necessary formwork for the front casting, if applicable, and shall fix it well in position and carry out casting of unreinforced concrete class K180 (aggregate gradation 37.5 mm to 3.2 mm) in accordance with the dimensions shown on the Drawing using Type V cement. After carrying out the front casting the Contractor shall execute the haunch in accordance with the same Specification as the front casting and over the remaining part of the foundation and dowels at the back of the kerbs, all in accordance with the Specifications, Drawings and instructions of the Engineer.

Expansion joints shall be provided at intervals of not more than 10 m and shall consist of pieces of Bituminised Celotex 10 mm thick complying with ASTM D1751 all in accordance with these Specifications, the Drawings

and as directed by the Engineer. The joint shall be continuous through foundation, kerb, haunch and front casting and no offsetting of parts of the joint will be acceptable.

Where shown on the Drawings, the rear face of the kerb foundation and haunch and the front face of the kerb foundation or front casting shall be painted with two coats of an approved bituminous paint complying with the requirements of Clause 517 of these Specifications.

505.03 TILES/PAVING SLABS

505.03.1 General

All units which are cracked, broken, warped, discoloured or improperly finished shall be rejected and promptly removed from site.

505.03.2 Laying and Constructing

Precast concrete units shall be according to the following steps:

a. Levelling of natural ground surface shall be done according to the proposed grades and slopes. Objectionable material and unsuitable soil shall be removed from the site.

b. Water shall be added and the soil shall be turned over and mixed thoroughly Compaction operations shall then commence until a minimum of 90% of the Maximum Dry Density is attained.

c. A bed layer of clean sand, average 50 mm thick shall be spread and water shall be added in order to obtain the required grades and levels before placing the concrete units.

d. Precast concrete units shall be placed directly on the sand layer without using any cement mortar.

e. In placing concrete units, care must be exercised so that no spaces shall be left between units. Sides of units shall be touching each other as close as possible.

f. Units shall be secured in place using light vibratory compactors in order to achieve the proposed levels and grades.

g. A thin layer of sand shall be utilized as filler between units. Water shall be sprayed to affix the sand in the voids.

h. Placing of units shall be carried out in lengths not exceeding 10 metre run in any direction, separated by full depth expansion joints incorporating 10mm thick bitumenised fibre board to AASHTO M213.

i. Concrete units shall be placed in a proper pattern. Units less than full size shall be machine cut or may be cast in situ if approved by the Engineer.

j. Additional or substitute pattern, if needed, can be used for laying units only after a written approval from the Engineer is obtained.

505.04 CONCRETE BLOCKS

505.04.1 Construction Requirements

Concrete blocks shall be hard, durable, sound, clean with sharp, well defined edges and free from any cracks, flaws or other defects. Solid blocks shall comply with the requirements listed in Table 505.04.1 herein.

Sampling and testing of concrete blocks shall be in accordance with ASTM C140. The Contractor shall provide all labour, materials, plants and all incidentals for construction in blockwork. The Contractor shall be responsible for covering and protecting the fair finished blockwork during the progress of the works and shall clean down the whole works upon completion, make good, point up and leave all perfect and to the satisfaction of the Engineer.

Concrete blocks shall be soaked with water before being used and the tops of walls left off shall be wetted before work is recommenced. The faces of walls shall be kept clean and free from mortar droppings and splashes.

Requirements	Values
1. Dimensions	
a. Height, mm	(200 or 250) ± 1%
b. Length, mm	(300 or 400) ± 1%
c. Width, mm	(100, 150 or 200) ± 1%
2. Compressive Strength at 28 Days	
a. for bearing walls	
(i) Average of 12 blocks, kg/cm^2	60
(ii) Minimum for any one block kg/cm^2	50
b. for non-bearing walls	
(i) Average of 12 blocks, kg/cm^2	30
(ii) Minimum for any one block kg/cm^2	25
3. Water Absorption	
a. Maximum for bearing walls, % of dry weight	14
b. Maximum for non-bearing walls % of dry weight	20

Table 505.04.1 – Requirements for Solid Concrete Blocks

Walls shall be carried up regularly without leaving any part more than one metre lower than another unless the permission of the Engineer is first obtained. Work which is left at different levels shall be raked back. In the case of cavity walls, both thicknesses shall be carried up together and in no case shall one thickness be carried up more than 400 mm in advance of the other.

The courses of blockwork shall be laid and jointed in the appropriate mortar with perfectly level horizontal joints. Each course shall be well flushed up with mortar throughout its full length and width. The vertical joints shall be properly lined and quoins, jambs and other angles plumbed, as the work proceeds. All walls shall be plumbed vertical.

Cut blocks shall not be used except where required for bond. Walls which are to be left unplastered shall have a fair-face consisting of selected blocks pointed with a neat weathered or flush joint upon completion, or as directed by the Engineer.

Walls which are to be plastered shall have the horizontal joints raked out to depth of 15 mm to form a key.

Where shown on the Drawings, masonry walls shall be reinforced and comply with the following:

i. Horizontal blockwork joints shall be reinforced with steel reinforcement complying with the requirements of ASTM A951, galvanized in accordance with the requirements of ASTM A153, Class B2, 458g/m2.

ii. Vertical reinforcement shall comply with the requirements of AASHTO M31.

iii. Unless otherwise shown on the Drawings, concrete infill for reinforced blockwork shall be grade K300 in accordance with Clause 502 of these Specifications.

iv. Hollow blocks for reinforced masonry walls shall comply with the requirements of Table 505.04.02.

Unless otherwise approved by the Engineer, reinforced masonry walls shall be brought up in lifts not exceeding 1.5m. Each lift shall be filled with concrete before the next lift is started. Concrete shall be of a consistency that will allow complete filling of the cells of the blocks and shall be compacted by rodding .

Cavity walls shall be built to the dimensions shown on the Drawings and the two thicknesses shall be bonded together with wall ties spaced one metre apart horizontally and approximately 400 mm apart vertically and staggered. Extra ties shall be provided at reveals, quoins and openings.

The ties shall be of the butterfly twist type 3.2 mm mild steel wire, zinc coated to comply with BS 1243. The length of the ties shall be approximately 80 mm less than the total thickness of the wall.

Requirements	Values
1. Dimensions	
a. Height, mm	(200 or 250) ± 1%
b. Length, mm	(300 or 400) ± 1%
c. Width, mm	(100, 150 or 200)±1%
2. Compressive Strength at 28 Days	
(i) Average of 12 blocks, kg/cm^2	60
(ii) Minimum for any one block kg/cm^2	50
3. Water Absorption Maximum % of dry weight	14

Minimum Thicknesses of Faces and Webs		
Nominal Width of Unit	Minimum Face Thickness	Minimum Web Thickness
100	19	19
150	25	25
200	32	25

Table 505.04.2 – Requirements for Hollow Concrete Blocks for Reinforced Masonry Walls

The cavity shall be kept clear by lifting boards or other means approved by the Engineer and shall be left clean at completion.

Block walls shall be bonded to columns by means of wall ties complying with BS 1243 which are previously cast in the Concrete. The ties shall be 200 mm long, with 100 mm embedded into the wall at the rate of one tie for each two courses of blockwork.

Allowances shall be made for leaving, temporarily, open courses immediately under all structural members built into the walls. These open courses shall be left in suitable positions to permit the structural members to take up their full deflection. The open courses shall be made good and pointed up after the structural members have been fully loaded and before the completion of the Works.

Walls shall be properly cured by spraying water or other curing method approved by the Engineer, for a period not less than 3 days after completion of laying of the courses.

505.05 MEASUREMENT AND PAYMENT

505.05.1 Method of Measurement and Basis of Payment

Measurement of precast concrete kerbstone shall be by the metre run for various types and classes.

Payment for precast concrete kerbstone shall include for all labour, plant and materials and everything necessary for the proper execution of the works including all necessary excavation of the kerb trenches, grading of trench bottom, upholding the sides of the kerb trench, removal of surplus excavation material, polyethylene sheet, dowel bars, backfilling, concrete beds, and backings, including any necessary formwork, providing and laying the kerbs including all transition kerbs, expansion joints, testing and all other incidental work in connection with the construction. Unless otherwise provided for in the Bills of Quantities, rates shall include for both straight and curved work.

Tiles/Paving Slabs - Measurement of tiles/paving slabs shall be by the metre square over all edge stones and cement mortar filler, but excluding kerbs at roadways which are measured separately. No deductions shall be made for voids or the like not exceeding 0.5 m2.

Payment for tile / slab paving shall be at the rate inserted in the Bills of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including foundation and bedding layers, supplying and laying the concrete tiles/paving slabs, providing and fixing all necessary expansion joints, associated edge stones (excluding kerbing laid to roadways which is paid for elsewhere), all cutting of tiles/paving slabs, cement mortar infill, trial areas, testing and all other incidental work in connection with the construction.

Measurement of concrete blockwork shall be by metre square for the various thicknesses and types of blockwork specified unless otherwise shown.

Payment for concrete blockwork shall be at the rate inserted in the Bills of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including supplying and laying the blocks, all necessary pointing, all cutting of the blocks, providing and fixing all necessary wall ties, reinforcement, infill concrete, keeping cavities clear of mortar in the case of cavity walls, temporary works, testing and all other incidental work in connection with the construction.

505.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
505.1	Precast concrete kerbs (type), (class)	m.
505.2	Tiles/paving slabs	sq.m.
505.3	Concrete blockwork (type), (thickness)	sq.m.

506 - INTERLOCKING PAVING BLOCKS

506.01 DESCRIPTION

This work comprises the laying of precast concrete interlocking paving blocks where shown on the Drawings and as specified herein.

506.02 MATERIALS REQUIREMENTS

506.02.1 Cement

Cement used for interlocking concrete blocks shall comply with Clause 501.06 of these Specifications.

506.02.2 Coarse Aggregate

Coarse Aggregate used for interlocking concrete blocks shall comply with Clause 501.04 of these Specifications. The gradation shall be as for prestressed concrete works, as specified in Table 501.04 of these Specifications.

506.02.3 Fine Aggregate

Fine aggregate used for interlocking concrete blocks shall comply with Clause 501.03 of the Specifications.

506.03 MANUFACTURE

506.03.1 General Requirements

All blocks shall be manufactured by an approved hydraulic press or mechanical vibration process resulting in a dense, compacted, homogeneous finished product. They shall be of a shape and colour as shown on the Drawings or approved by the Engineer.

Interlocking blocks shall be made from concrete Class K300 except that approved pigments shall be incorporated to achieve the specified colour. They shall be finished, transported and stored in accordance with Clause 505.01 of these Specifications.

All interlocking blocks which are chipped, cracked, broken, warped, discoloured, improperly finished or which do not comply with dimensions and tolerances specified herein or on the Drawings shall not be used in the Works and shall be promptly removed from the Site by the Contractor at his expense.

506.03.2 Approval of Blocks

Before commencement of the work, the Contractor shall submit to the Engineer for approval the following:

a. A minimum of 12 No. of each type and shape of interlocking block required for the works including samples of coloured blocks when specified.

b. Warranties from the manufacturer regarding his ability to consistently attain the compressive strength, dimensional tolerances, colour and surface finish requirements specified herein.

c. Certificates from an independent testing laboratory certifying that interlocking blocks meet the requirements of these Specifications.

Sample blocks, and blocks from site deliveries will be tested for compressive strength, thickness, and water absorption in accordance with KSS 222 and KSS223.

506.03.3 Dimensions and Tolerance

Interlocking paving blocks shall be of the shape and dimensions shown on the Drawings or selected by the Engineer from manufacturer's products.

Each side of the block shall be normal to the top and bottom faces of the block. The thickness of the block i.e. the dimension between the top and bottom faces of the block shall not very by more than +3 mm from the specified thickness and measurements of thickness taken at any location within the plan area of the block shall not vary from each other by more than 1 mm.

506.04 TRIAL AREAS OF INTERLOCKING PAVING BLOCKS

Trail areas of interlocking paving blocks shall be constructed to determine the amount of bedding layer surcharge required. The trail area shall also demonstrate the pattern required for the works and construction method abutting manholes and traffic signs, etc.

Each trial area shall be approximately ten square metres. The blocks shall be laid to a pattern required for the works and designated by the Engineer. The construction materials and method shall be identical to that proposed for the works. The amount of sand overfill to be used (to allow for compaction during laying) shall be determined by the Contractor. The surface of the completed area shall be checked for level, grade and evenness and the pattern checked for acceptability by the Engineer. The process shall be repeated until acceptable results are obtained and the required overfill has been determined. Once the required overfill has been determined, the Contractor shall ensure that the bedding layer material to be used is protected from changes of moisture content or any other effect to the material.

The method of construction of the interlocking paving block areas as determined by the trial areas shall not be amended without the approval of the Engineer. Notwithstanding the acceptability of the trial area it shall be the Contractor's responsibility to ensure the finished interlocking paving block areas comply with the requirements of the Specifications.

506.05 INSTALLATION OF INTERLOCKING BLOCKS

506.05.1 Description

Laying interlocking blocks shall be in accordance with the following steps unless otherwise directed by the Engineer.

a. The Contractor shall raise or lower the existing ground to the bottom of subgrade elevation in accordance with Section 2 (Earthworks) of these Specifications. The Contractor shall place 200 mm of subgrade material in two layers of 100 mm each.

b. The subgrade material and compaction of each layer shall be in accordance with Clause 206 of Section 2 (Earthworks) (Subgrade Construction) of these Specifications except that measurement and payment of subgrade shall be as described in Clause 506.07 of these Specifications. The Contractor shall construct all edge restraints (kerbs or sidewalk edge stone) prior to placing sand bedding layer and interlocking blocks.

c. The Contractor shall place a bedding layer of uncompacted, coarse, well graded sand over the compacted subgrade. The depth of the uncompacted bedding layer including overfill shall be as determined from the trial areas of interlocking blocks. The sand shall be spread to a uniform grade.

d. The interlocking blocks shall be placed in the pattern the Engineer has selected as close together as possible such that the spaces of the joints do not exceed 3 mm. The spaces shall be consistent so that the pattern as applicable remains constant.

e. The surface of the blocks shall then be covered with a layer of sand having a grading within the limits of Table D3 of BS7533 Part 3, as copied below, which shall be vibrated into the gaps between the blocks using a plate vibrator as described below. Watering-in of the sand will not be permitted.

Laying course material category	I	II	III	IV
Percentage by mass passing 0.063 mm	1.0	1.5	3.0	4.0
BS EN 12620:2002 fines content category	$f_{1.0}$	$f_{1.5}$	f_3	f_4

Table D.3 – Fines content of laying course material for conventional pavements

The resistance to wear of category I sand shall be subject to the wear regime in Annex G of BS7533 Part 3.f.

The interlocking blocks (now higher than required by the predetermined depth of overfill) shall be tamped down and levelled with a mechanical plate vibrator until blocks are uniformly level, true to grade and free of any movement and all gaps between the blocks are filled with sand. The mechanical plate vibrator shall have a plate area of 0.20 to 0.35 m2 and have a compaction force of 12-24 KN. Vibratory compaction shall not be carried out within one (1) metre of an unrestrained or unfinished edge. Finally, the excess sand shall be swept from the surface and the area shall be left clean and tidy.

g. At gully gratings, manholes or other such obstructions, the concrete blocks shall be carefully machine cut to fit. Small gaps left at the edges of the paved area, including against obstructions, shall be filled to the full depth of the paving block with 3:1 sand-cement mortar matching the colour of the blocks, fully compacted into the gap. The Contractor shall demonstrate that colour consistency of the mortar matches that of the interlocking blocks as specified by the manufacturer.

506.05.2 Cutting of Interlocking Blocks

If necessary, cutting of interlocking blocks shall be done with a concrete saw to obtain the true, even and undamaged edges. Hand-cut or blocks with ragged or flaked edges shall not be accepted. Block splitter used for cutting will not be allowed without the permission of the Engineer.

506.06 ACCEPTANCE CRITERIA FOR LEVELS GRADE AND EVENNESS OF SURFACE

The areas paved with interlocking blocks shall be checked for levels, grade and evenness of surface. Any areas not conforming to the requirements herein shall be taken up and re-laid at the Contractor's expense.

The level of the finished surface at any point shall not vary by more than 10 mm from the required level. In addition the variation in falls of the surface shall not vary from the required values by more than 0.3%.

The evenness of the finished surface for flat areas shall be assessed by a 4 metre straight edge. When placed on the surface (in any orientation) the variation of the surface from the straight edge between any two contacts with the surface shall not exceed 6 mm. For contoured areas the acceptability of the evenness of the finished surface shall be judged by the Engineer on the basis of visual inspection. The Engineer's decision will be final.

506.07 MEASUREMENT AND PAYMENT

506.07.1 Method of Measurement and Basis of Payment

Measurement of interlocking concrete paving blocks shall be by the metre square of specified thickness overall edge restraints and cement mortar filler but excluding kerbs of roadways which are measured separately. No deductions shall be made for voids or the like not exceeding 0.5 m2.

Payment shall be at the rate inserted in the Bills of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including foundation, subgrade and bedding layers, supplying and laying interlocking blocks of any type, shape and color, providing and fixing all

necessary expansion joints, edge restraints (excluding kerbing laid to roadways which is paid for elsewhere), filling joints with sand vibrated into place, cement mortar infill, testing and all other incidental work in connection with the construction.

No measurement and payment shall be made for trial areas of interlocking blocks. The cost of such work shall be included in the rates for the items in Section 5 of the Bills of Quantities.

506.07.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
506. 1	Interlocking paving blocks (thickness)	sq.m.

507 - CONCRETE TESTING

507.01 GENERAL REQUIREMENTS

In addition to all previously mentioned tests the following tests shall be carried out. All tests must be carried out in a manner and as directed by the Engineer. The Contractor shall bear all expenses involved in obtaining cutting-out or sampling all specimens and/or component parts for testing.

507.02 TEST CUBES

Works test cubes shall be taken and tested as specified in BS EN 12350 and BS EN 12390.for each new grade of concrete or from each 100 metre cube of concrete when the same grade is being used continuously, or as directed by the Engineer. Nine 150 mm test cubes shall be taken at each time and numbered consecutively and marked with the date, the section of work from which it was taken and any other information required and dispatched to the approved laboratory for testing for compressive strength. Cubes Nos. 1, 5 and 9 shall be tested after 7 days.

Cubes Nos. 2 and 8, 3 and 7 and 4 and 6 will be considered three individual samples or sets for testing at 28 days. If either of the cubes in any set shows definite evidence, other than low strength, of improper sampling, moulding, handling, curing or testing, it shall be discarded and the strength of the remaining cube shall then be considered the test result for that set.

If the average of the three 7 days cubes is below the minimum requirement the Contractor must immediately stop all concreting until checks are made on the material and equipment and immediately rectify any defect which has become apparent as the result of such checking. If so approved by the Engineer concreting may then continue entirely at the responsibility of the Contractor. However the Contractor may elect to remove and replace all defective concrete without waiting for the 28 day cube tests.

Final acceptance of the concrete work will be based on 28 days testing of the three sets of two cubes each. The work will be considered in compliance if the average of the three sets of cubes equals or exceeds the minimum specified for the class of concrete being placed and if the average of the two cubes in any one set does not fall below the specified minimum strength by more than 35 kg/cm2. If the result of the 28 day test is unsatisfactory, all concreting shall be stopped at the Contractor’s expense and shall not proceed further without the written permission of the Engineer. The Contractor shall conduct tests in the suspect parts of the structure in such a manner as may be appropriate to the particular conditions or parts of the work. The concrete may be test loaded in situ or cylindrical test cores may be taken and tested in accordance with BS EN 12504. Should the tests prove that the concrete is unsatisfactory and/or below the standards specified, or should the Engineer judge that any sections of the concrete works are defective, then the condemned concrete shall be cut out, removed and replaced by the Contractor at his own expense.

507.03 DURABILITY TESTING

507.03.1 Absorption Test

Hardened concrete from the trial mixes for structural grades shall be tested for absorption to establish the concrete’s ability to resist the ingress of aggressive salts. No absorption tests shall be required for concrete Class K180, plain concrete or cyclopean concrete. Absorption tests shall be in accordance with modified BS 1881: Part 122.

507.03.2 Permeability Tests

1. Depth of penetration tests shall be carried out to establish the water permeability of concrete on prototype samples of different components of the structure before the mix design or manufacturing method are approved. The prototype samples shall be short sections of not less than 1.0m x 1.0m x full thickness. The samples shall be fully reinforced and cast in similar environment as the actual structure. The tests shall be carried out in accordance with DIN 1048 at age 28 days and the maximum value of penetration shall not exceed the following limits:

   In-situ construction: 25 mm.

   Precast units: 20 mm

2. Chloride permeability of the concrete shall be determined using cores taken from the prototype samples, in accordance with AASHTO T277 "Rapid Determination of the Chloride Permeability of Concrete". The following limits shall not be exceeded:

   In-situ construction: 1500 coulombs.

   Precast units: 1000 coulombs.

3. The concrete will be deemed to comply with the permeability requirements of this Specification if all test results comply with the limits indicated in Points 1 and 2.

4. If any of the DIN 1048 and the rapid chloride permeability test results of unprotected surfaces of a sample failed to meet the above requirements, then all the concrete work represented by such sample shall be deemed not to comply with the permeability requirements.

5. If, in the opinion of the Engineer, the concrete that has failed to meet the permeability requirements of this Specification is likely to cause durability problems, three cores shall be cut from the area represented by failed samples for additional DIN 1048 and rapid chloride permeability testing. The location of the cores shall be decided by the Engineer.

507.04 MEASUREMENT AND PAYMENT

507.04.1 Method of Measurement and Basis of Payment

The works prescribed in this section shall not be measured for direct payment but shall be considered as subsidiary works the cost of which will be deemed to be included in the Contract prices for the relevant Bills of Quantities Items for concrete described and measured for payment under the provisions of these Specifications as described in Clause 504.08 of these Specifications.

508 - SUPERSTRUCTURE CONSTRUCTION

508.01 CONCRETE BOX GIRDER

The sequence for placing concrete for the cast-in-place, multiple cell, concrete box girders at bridges shall be as follows: first, the bottom slab, the exterior and interior web portions and the diaphragm portions shall be placed monolithically as indicated on the Drawings and as specified herein; second, the roadway or top slab shall be placed.

Vertical construction joints in all portions of the multiple cell box girders shall be minimized and where proposed shall preferably be placed at 0.2 of the span length on either side of a supporting pier. The positive moment areas shall be placed first followed by the placement of concrete for the negative moment area over the pier. Dependent upon the volume of concrete, additional vertical construction joints may be used all subject to approval of the Engineer.

A concrete pour sequence plan shall be prepared by the Contractor for each superstructure and submitted to the Engineer for approval prior to commencing any bridge superstructure work. The pour sequence plan shall show the locations of all construction joints which shall be bonded joints as specified herein. Concrete pours within each element shall be alternated to eliminate the effects of shrinkage to the greatest extent possible.

The placing of concrete in each pour shall start at the low point and shall proceed upgrade, unless otherwise permitted by the Engineer.

Joints in the concrete due to stopping work shall be avoided as far as possible. Such joints, when necessary, shall be constructed as directed by the Engineer.

At deck median locations shown on the Drawings a commercial quality, bond breaking compound shall be applied to construction joint surfaces unless otherwise shown on the Drawings or directed by the Engineer.

Measurement and payment for concrete box girder construction shall be as stipulated in Section 11, (Prestressed Concrete Works) of these Specifications.

508.02 PLACING CONCRETE FOR BRIDGE DECKS

On bridge decks a surface true to the required grade and cross section shall be obtained.

For carriageways a finishing machine manufactured specifically for bridge deck finishing shall be used. For sidewalks, medians and other similar areas hand operated tools may be used subject to the approval of the Engineer.

Finishing of concrete placed in bridge decks shall consist of striking off the surface of the concrete as placed, floating the surface so struck off when specified and finishing as specified herein.

The placing of concrete in bridge roadway decks will not be permitted until the Engineer is satisfied that the rate of producing and placing concrete will be sufficient to complete the proposed placing and finishing operations within the scheduled time, that experienced finishing machine operators and concrete finishers are employed to finish the deck, that fogging equipment and all necessary curing and finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. Finishing machines shall be set up sufficiently in advance of use to permit inspection by the Engineer during daylight hours.

Rails for the support of finishing machines and headers for hand-operated strike off devices shall be completely in place and firmly secured for the scheduled length of concrete placement before placing of concrete will be permitted. Rails for finishing machines shall extend beyond both ends of the scheduled length of concrete placement for a sufficient distance that permits the float of the finishing machine to fully finish all of the concrete surface, unless otherwise approved by the Engineer. Rails or headers shall be adjustable for elevation and shall be set to elevations, with allowance for anticipated settlement, camber, and deflection of falsework, as required to obtain a bridge roadway deck true to the required grade and cross section. Rails or headers shall be of a type and shall be so installed that no springing or deflection shall occur under the weight of the finishing equipment and shall be so located that finishing equipment may operate without interruption over the entire bridge roadway deck being finished. Rails or headers shall be adjusted as necessary to correct for unanticipated settlement or deflection which may occur during finishing operations.

The Contractor shall form and place all concrete on bridge decks to conform to all lines, levels, profiles as shown on the Drawings and shall include all depressions or notches to receive expansion joints as shown and as specified in Section 13 (Bearings and Expansion and Fixed Joints) of these Specifications.

Immediately prior to placing bridge deck concrete, the Contractor shall check all falsework and formwork and shall make any necessary adjustments. Settlements and deflections shall be uniform in any span and shall not normally be greater than 20 mm. Suitable means such as telltales shall be provided by the Contractor to readily permit measurement by the Engineer of settlement and deflection as it occurs.

In the event that large or non-uniform settlements occur which would, in the opinion of the Engineer, prevent the obtaining of a bridge deck conforming to the requirements of these Specifications, placing of deck concrete shall be discontinued until corrective measures satisfactory to the Engineer are provided. If the Contractor fails to provide satisfactory measures prior to initial set of the concrete in the affected area, the placing of concrete shall be discontinued and the concrete already placed in the pour shall be removed.

Concrete for bridge decks shall be placed in a uniform heading approximately normal to the structure centerline or, in the case of screeds supported on transverse headers, parallel to the centreline as directed by the Engineer. The rate of placing concrete shall be limited to that which can be finished before the beginning of the initial set.

Immediately after the concrete has been placed and compacted, the surface shall be struck off with the finishing machine or hand-operated screed until the required surface is obtained.

The strike off method and equipment shall be subject to approval by the Engineer. Approval shall be withdrawn if performance is not satisfactory. The equipment shall be capable of finishing roadway decks within the surface tolerances set forth in these Specifications. Improper adjustment and operation which results in unsatisfactory compaction and smoothness shall be corrected immediately. Unsatisfactory performance may be cause for rejection of the equipment and removal of the placed concrete at the Engineer's discretion.

Where directed by the Engineer, and following the completion of the strike off, the slab surface shall be floated to a smooth uniform surface by means of floats 3 metres or more in length. When a finishing machine is used, the finished surface shall be floated in a similar manner unless otherwise directed by the Engineer. Adequate floats shall be used to remove roughness and minor irregularities left by the strike board or finishing machine and to seal the concrete surface. Excessive working of the concrete surface shall not be permitted. All floats shall be used in such a manner that each transverse pass overlaps the previous pass by a distance equal to or at least one-half the length of the float.

When hand-operated float boards are used they shall be from 3.5 metres to 4.5 metres long braced as necessary to provide a rigid float and shall be equipped with adjustable handles at each end. The float shall be wood, not less than 25 mm thick and a minimum of 200 mm wide. Adjusting screws spaced at not to exceed 600 mm on centres shall be provided between the float and the rib. The float board shall be maintained true and free of twist at all times.

Hand-operated float boards shall be operated from transverse finishing bridges. The finishing bridges shall span completely the roadway area being floated and a sufficient number of finishing bridges shall be provided to permit operation of the floats without undue delay. Not less than 2 transverse finishing bridges shall be provided when hand-operated float boards are used. When a finishing machine is used for longitudinal floating, one finishing bridge equivalent to the transverse finishing bridge specified herin shall be furnished for use by the Engineer.

All finishing bridges shall be of rigid construction and shall be free of wobble and springing when used by the operators of longitudinal floats and shall be easily moved.

After the floating has been completed but while the concrete is still plastic, the slab surface shall be tested with a 4 metre straightedge which shall be held in contact with the surface in successive positions parallel to the roadway centerline and then at right angles to it. The whole area shall be tested from one side of the slab to the other. Testing along and across the deck shall be in successive stages of not more than one-half the length of the straightedge. Any depressions found shall be filled at once with fresh concrete, compacted, struck off, and refinished. High areas shall be cut down and refinished. The testing and refinishing shall continue until the entire surface is found to be free from deviations of more than 6 mm under the 4 metre straightedge.

Allowance shall be made for crown, camber and vertical curvature. Any straight edging and corrective work performed on the plastic concrete does not relieve the Contractor of meeting the smoothness requirements on the hardened concrete as outlined hereinafter.

If directed by the Engineer the exposed concrete bridge deck surface and approach slabs shall be finished as above, except that the surface shall be textured by use of a hessian or artificial turf carpet drag followed immediately by a mechanically or hand-operated, metal comb transverse grooving device. The textured finish shall be obtained as follows:

a. The hessian or artificial turf shall be suitably attached to a bridge, riding on rails, or other approved device that will permit control of the time and rate of texturing. The burlap or artificial turf carpet shall have a length equal to the width of the pour or from face-to-face of kerblines, as applicable. The hessian or carpet shall be laid on the concrete surface and dragged, parallel to the centerline of the roadway, in the direction that the deck is being laid with approximately 600 mm of its width in contact with the concrete surface. The drag shall be operated so as to produce a uniform appearing finish meeting the approval of the Engineer. The hessian shall be double thickness and shall be kept saturated with water while in use. The artificial turf carpet may be weighted, if necessary, for maintaining intimate contact with the concrete surface.

b. The metal comb shall consist of a single line of tempered spring steel tines spaced at 20 mm centres and

securely mounted in a suitable head. The tines shall be of a size and stiffness sufficient to produce a groove of the specified dimensions in the plastic concrete without tearing of the surface. The metal comb shall be drawn transversely across the width of the portion of the bridge deck requiring a groove finish in a single pass at a uniform speed. The grooving device shall be operated so as to produce a relatively uniform pattern of grooves perpendicular to the roadway centreline spaced at approximately 20 mm centres, 3 mm to 5 mm deep and 2 mm to 3 mm wide. The grooving shall be stopped 30 mm from the faces of the kerblines.

Fogging equipment to be furnished shall be capable of applying water to the concrete in the form of a fine mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the deck resulting from wind, high temperature or low humidity, or a combination of these factors. The fog mist shall be applied at the times and in the manner directed by the Engineer.

Concrete barriers and parapets shall not be placed until the centering or falsework for the span has been released. Special care shall be exercised to obtain smooth and tight-fitting forms which can be held rigidly to line and grade and can be removed without injury to the concrete.

All mouldings, panel work, and bevel strips shall be constructed according to the detail plans, with neatly mitred joints. All corners in the finished work shall be true, sharp, and clean-cut and shall be free from cracks, spalls, or other defects.

Concrete for sidewalk and median slabs shall be well compacted, then struck-off with a strike board and floated with a wooden float. An edging tool shall be used on all edges and at expansion joints. The surface shall not vary more than 4 mm under the 4 metre straight edge. The surface shall be lightly broomed to a granular texture which will not be slippery when wet.

508.03 BALANCED CANTILEVER CONSTRUCTION WITH IN-SITU CONCRETE

508.03.1 General

This work consists of installing temporary bearings, casting concrete units in-situ and setting the superstructure on permanent bearings. The Contractor shall submit complete details and descriptions of all methods, arrangements and equipment which he intends to adopt, for approval before construction work is started..

The construction method statement shall include casting of units, method of the tie-down of superstructure during cantilever construction, method of application of all temporary forces to be used for adjusting horizontal and vertical alignment and to place the structure on permanent bearings, details of work plans and safety measures. It shall also include control methods to ensure the accuracy of alignments of the constructed superstructure.

Construction equipment and other loads shall not be placed upon any part of the superstructure at any stage of construction other than that which specifically meets the requirements of total working load per unit, or has the approval of the Engineer. This includes the post-tensioning, jointing, jacking, grouting equipment, any other equipment whatsoever, workmen and materials of any kind.

Unbalanced Load: During construction the cantilever may be unbalanced by only one unit at any time and be consistent with the holding-down method adopted. In addition to the unbalanced load due to one unit, 0.5 kN/m2 load is permissible anywhere on the cantilever. This load includes workmen, miscellaneous equipment and stored materials. The Contractor shall take care to ensure that this allowable load is not exceeded

508.03.2 Construction Schedule

The Contractor shall submit a construction schedule showing the order of every phase and stage of erection and construction of the superstructure. The Contractor shall prepare a table of elevations and alignments required at each stage of construction at the check points listed below, or an alternative of his choice and submit the same for the Engineer's approval. The check points are:

- One of the lowest corners at the top surface of any temporary bearing pad which is to be used as datum during construction.
- All four corners of the top slabs of the pier units to establish grade and top levels.
- Two points on the longitudinal center line of each pier unit, one on each end to establish alignment.

- One point on the longitudinal center line, and at least on one corner of each unit along every joint between cast-in-place units to establish elevations and alignments at every stage of construction.

The alignment and elevations of the cantilever shall be checked by the Contractor and the Engineer independently within 1 hour of sunrise on each day that the units are to be cast. The measurements made by the Engineer and the Contractor shall agree to within 5 mm.

The temporary bearing pads at the piers shall be carefully placed. The top surface of these pads must have the correct elevations, alignments and slopes as required by the working drawings and as established by the procedure described above. Shims may be used underneath the pads to accomplish accuracy. The Contractor shall check elevations and alignment of the structure at every stage of construction and shall maintain a record of all these checks and of all adjustments and corrections made.

508.03.3 Casting Procedures

Casting of the units shall not begin until approval of the shop drawings, calculations and the post-tensioning system has been given.

Sequence: The units shall be match cast beginning with each pier unit. After the pier unit is cast all units on either side of the pier unit may be cast in order so long as match casting is maintained.

Care shall be taken in the set-up of each unit. All materials to be encased within the concrete of the segment shall be properly positioned and supported. Before any concrete is placed, the set up will be inspected and checked by the Engineer. All ducts shall be located within 3mm of the location given on approved drawings. The top surface of the units shall be free of depressions or high spots.

Forms shall not be removed until the concrete has achieved the specified compressive strength and has been proved by test cubes made and cured in the same manner as the unit. Care shall be taken in removing the forms to prevent spalling and chipping of the concrete.

508.03.4 Tolerances

Formwork for box girder segments must satisfy the following tolerances:

- Web thickness, +10 mm or -5 mm.
- Thickness of bottom slab +5 mm, but 0 reduction in depth.
- Thickness of top slab +5 mm, but 0 reduction in depth.
- Overall width of unit, ±5 mm.
- Overall depth of unit, ±5 mm.
- Length of match cast unit, ±10 mm, but not cumulative and a maximum of 50 mm per span.
- Diaphragm dimensions, +10 mm or -5 mm
- Grade at top and bottom flanges, ±3.

After erection, final post-tensioning, final corrections and adjustments are completed and the structure has been placed on its permanent bearings, the superstructure shall conform to the grade and alignment shown on the working drawings with due consideration for creep and superimposed load and dead load deflections within a tolerance of ± 5 mm horizontally and ± 10 mm vertically.

508.04 GLUED PRECAST SEGMENTAL CONSTRUCTION

Follow the requirements of sub-section 8.16 of AASHTO LRFD Bridge Construction Specifications as complemented and/or modified herein.

Where bridge decks are precast in segments and assembled in position for glueing and stressing, the Contractor shall satisfy the Engineer that his proposed construction method will achieve the required standard of workmanship and finish in the time available. The Contractor shall submit details for approval of all his forms, falsework, precasting factory and his method of lifting, transporting, assembling, supporting, threading cables, glueing and stressing the precast units before commencement of any work.

Epoxy Adhesive

The epoxy resin adhesive shall be supplied by an approved manufacturer. It shall be made up and packaged by

approved formulators and to Specifications agreed by the Engineer. The material shall be supplied in accurately measured packs with the pack containing the hardener clearly distinguished by both size and labelling. The pack containing the resin shall be large enough to permit the addition of the hardener. Resin and hardener shall be pigmented with dissimilar colours to indicate when even mixing has been completely attained and to produce an even gray colour to match the concrete. Each batch of resin mixed shall be tested for setting by compression and shear tests as described below. No permanent prestress shall be applied to a joint until the epoxy has achieved the required strength. Should this test show that the resin is not setting the joint shall be broken and the resin removed. Set resin shall be removed by grit blasting. Further tests may be requested by the Engineer at various times to ensure that the material as mixed is complying with the Specification. All the instructions of the manufacturer and/or the formulator shall be submitted to the Engineer for agreement. Such agreed instructions shall be adhered to in all respects. The supplier shall carry out a program of testing as described in Fédération Internationale du Béton (fib) "Proposal for a standard for acceptance tests and verification of epoxy bonding agents for segmental construction", after consultation with the Engineer on the range of temperatures and work cycles that are to be considered in the tests. The Engineer may require the tests to be witnessed either in person or by an approved independent authority.

Surface Preparation

The interface of the units shall be lightly grit blasted before erection to remove laitance. Before applying the epoxy the interfaces must be clean and free from laitance or any bond breaking material. Any oil or grease which may be harmful shall be removed. The surface shall have no free moisture.

Application of Epoxy

Application shall begin immediately after a batch has been mixed. Application shall be to both interfaces to a total nominal thickness of 2 mm with a spatula or by hand. No epoxy may be applied within 25mm of any duct.

Preliminary Prestress

Immediately after the interfaces are coated with epoxy, the unit shall be brought into position and the preliminary prestress applied. This preliminary prestress is to be just sufficient to start squeezing epoxy resin out of the joint. The amount of prestress required will depend on the formulation of resin chosen by the Contractor. If this operation is not completed within the life time of the first batch of epoxy to be applied, the units shall be moved apart. All the epoxy on both interfaces shall be removed with spatulas and an approved solvent. No epoxy may be applied to the joint until 24 hours after a solvent has been used. The life time shall be reckoned from the end of the pot life unless the manufacturer's instructions direct otherwise. All excess epoxy shall be cleaned off from the outer faces of the webs and the soffit in such a way as not to smear the concrete face.

Records of Joining

The Contractor shall keep a record of each joint with the following details:

i. Joint Number,

ii. Date and Time of jointing,

iii. Batch number of resin and hardener,

iv. Weather conditions (temperature and humidity) continuously recorded,

v. Results of tests.

Tolerances: These shall be similar to those prescribed for balanced cantilever construction.

508.05 PRECAST BEAM AND SLAB CONSTRUCTION

Manufacture of Prestressed Beams:

i. The details of method of manufacture shall be approved by the Engineer before work is started. No changes shall subsequently be made without the consent of the Engineer.

ii. The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and the dates when tensioning of tendons, casting of members and transfer of stress will be undertaken for the first time for each type of beam.

iii. The Contractor shall submit to the Engineer, not more than 7 days after the transfer of stress, a certificate showing the force and strain in the tendons immediately after they were anchored, the strength and age of the test cubes cast in accordance with this Specification, and the minimum age in hours of the concrete at the time stress was applied to the members. Copies of all 28 day cube test results relating to the work shall be kept so that the identity of those who stressed the tendons, cast the concrete and transferred the stress, on any member or line of members, can be traced.

iv. Where the Engineer requires tests to be carried out on beams, the beams to which these tests relate, shall not be dispatched to Site until the tests have been satisfactorily completed.

Storage and Handling of Prestressed Members

Members shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Members shall be lifted or supported only at the points specified and shall be handled and placed without impact.

Tolerance in Precast Members

Dimensional Variations shall not exceed the tolerances given below:

- Length	± 12 mm
- Width and depth	± 6 mm
- Bow in the vertical plane	+ 15 mm or -0 mm
- Bow in the horizontal plane	± 12 mm
- Difference between longest and shortest dimensions (check for squareness of beam) in any plane	6 mm
- Twist (measured by the deviation of any corner from the plane containing the other 3 corners)	6 mm
- Flatness (the maximum deviation from a 1.5 meter straight-edge placed in any position on nominally plane surface)	6 mm
- Cover to reinforcement	+5 or -0 mm
- Prestressing tendons	3 mm in any direction
- Dowel holes	3 mm in any direction

Composite Slab Construction

i. Where in-situ concrete deck is cast to act compositely with precast beams, the beams shall be installed to correct line and level, starting from the outermost beam and working inwards progressively. When the beams are laid side by side just before erection, the difference in soffit level between adjacent beams shall nowhere exceed 6 mm. Where permanent soffit shutters are used, they shall be to the approval of the Engineer and they shall be fixed securely so that there is no movement or grout loss during deck concreting.

ii. The in-situ concrete deck over any one span shall be poured in one continuous operation and shall be placed in such a sequence that the advancing edge of the freshly deposited concrete over the full width of deck or between longitudinal construction joints is approximately parallel to the deck supports. Lateral displacement of beams shall be prevented during the placing of in-situ concrete.

iii. The width of the in-situ deck shall be within +25 mm of that specified. On curved bridge deck, the in-situ deck may be in a series of straights such that the width is within +25 mm of that specified.

508.06 IN-SITU CONSTRUCTION

Where bridge decks are constructed in-situ, the details of all forms and falsework shall first be approved by the Engineer. Dimensional variations shall not exceed the following tolerances:

- Length ± 12 mm
- Width ± 10 mm
- Thickness ± 6 mm
- Levels + 10 mm or -0 mm
- Void Location 6 mm in any direction
- Cover to reinforcement + 5 mm or -0 mm
- Prestressing tendons 5 mm in any direction

508.07 MEASUREMENT AND PAYMENT

508.07.1 Method of Measurement and Basis of Payment

The works prescribed in this section shall not be measured for direct payment but shall be considered as subsidiary works the cost of which will be deemed to be included in the Contract prices for the relevant Bills of Quantity Items for concrete described and measured for payment under the provisions of these Specifications as described in Clause 504.08 of these Specifications and in Clause 1104 of Section 11 (Prestressed Concrete Works) of these Specifications.

509 - APPROACH SLABS

509.01 GENERAL REQUIREMENTS

Approach slabs shall be constructed as shown in the Drawings and as directed by the Engineer. Concrete use for approach slabs shall be minimum Class K350 as specified herein and shall be placed on aggregate base course, as specified in Section 3 (Sub-base and Base Courses) of these Specifications or as shown on the Drawings. The requirements for evenness of surface, method of testing, and surface finishing all conform to the Specification for bridge decks included herein.

509.02 MEASUREMENT AND PAYMENT

509.02.1 Method of Measurement and Basis of Payment

Measurement of reinforcing steel shall be as Clause 504.02.8 of these Specifications, and measurement of concrete work shall be as Clause 504.08 of these Specifications.

Aggregate base course shall be paid for under Section 3(Sub-base and Base Courses) of these Specifications.

510 - GROUT PADS

510.01 GENERAL REQUIREMENTS

When bearing plates are to be placed on grouted pads as shown on the Drawings, the concrete bearing area shall be constructed to a plane surface which shall not vary perceptibly from a straightedge placed in any direction across the area. The finished plane shall not vary more than 3 mm from the elevations shown on the Drawings.

Before placing the grout pad, the concrete areas to be in contact with the grout shall be thoroughly cleaned of all loose and foreign material and laitance that would in any way prevent bond between the grout and the concrete surfaces, and shall be kept thoroughly moistened with water for a period of not less than 24 hours immediately prior to placing the grout.

Grout shall consist of a pre-bagged, proprietary, free-flowing, non-shrink, cementitious grout specially formulated for the grouting of bearing baseplates. The grout shall be used strictly in accordance with the manufacturer’s instructions.

A form shall be constructed to the dimensions shown on the Drawings and to the height of the bottom of the bearing plate or pad. Grout shall then be placed using great care to work the grout into the form and filling the

form to the top. The exposed surface of the grout shall be given a steel trowel finish. The form shall remain undisturbed and the grouted area shall be kept damp with no load for a minimum period of 72 hours.

510.02 MEASUREMENT AND PAYMENT

510.02. 1 Method of Measurement and Basis of Payment

No separate measurement and payment will be made for grout pads and the cost of all labour, materials and equipment required is deemed to be included in the rates for other items as shown in the Bills of Quantities.

511 - WATERSTOPS

511.01 CONSTRUCTION REQUIREMENTS

Waterstops shall be furnished and installed in accordance AASHTO LRFD Bridge Construction Specifications Article 8.9.2.6 and with the details shown on the Drawings, the provisions in these Specifications and as directed by the Engineer.

Waterstops shall conform to the cross section and to the minimum dimensions shown on the Drawings.

Waterstops shall be manufactured either from rubber, neoprene or from polyvinyl-chloride (PVC), at the option of the Contractor.

PVC waterstops of the hollow centre bulb type shall be manufactured from low-modulus PVC, where so described on the Drawings.

Self-Expanding Strip Waterstops: Manufactured rectangular or trapezoidal strip, sodium bentonite or other hydrophylic material for adhesive bonding to concrete.

Re-injectable Hosing: Re-injectable hosing shall be used where shown on Drawings. Re-injectable hosing shall comply with the following requirements:

- The hose shall consist of a hollow PVC core with lateral openings covered by neoprene valves. The hose shall be applied in 10 to 12 m lengths with entry port and vent ends terminating in junction boxes. The hose shall permit the option of re-injection. The hose shall be laid and injected by an approved applicator.

- The joint shall be hydraulically tested to a pressure at least 2.0 bar higher than the expected local conditions. If the hose fails to hold the pressure for 10 minutes, the hose shall be injected with a vinyl ester based flexible resin as required to seal the joint and then retested.

Install waterstops in accordance with AASHTO LRFD Bridge Construction Specifications Article 8.9.3.4.

Flexible Waterstops: Install in construction joints as indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of work. Field-fabricate joints in waterstops according to manufacturer's written instructions.

Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, bonding or mechanically fastening and firmly pressing into place. Install in longest lengths practicable.

No splices will be permitted in straight strips without the permission of the Engineer. Strips and special connection pieces shall be well formed in a manner such that any cross section shall be dense, homogeneous and free from all porosity. All junctions in the special connection pieces shall be full moulded or factory welded. During forming, the joints shall be securely held by suitable clamps. The materials at the splices shall be dense and homogeneous throughout the cross section.

If, after placing concrete, waterstops are materially out of position or shape, the surrounding concrete shall be removed, the waterstop reset, and the concrete replaced, all at the Contractor’s expense.

Field splices for neoprene waterstops shall be either vulcanized mechanical, using stainless steel parts; or made with a splicing union of the same stock as the waterstop, at the option of the Contractor.

Field splices for polyvinyl-chloride waterstops shall be performed by heat welding the adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt but not char the plastic.

Waterstops when being installed shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion of the web or flange.

Field splices shall develop watertightness equal to that of the unspliced material and have a tensile strength of not less than 50% of the unspliced material.

511.02 MEASUREMENT AND PAYMENT

511.02.1 Method of Measurement and Basis of Payment

No separate measurement and payment will be made for waterstops and all work including furnishing and placing is deemed to be included in the rate for concrete items in the Bills of Quantities.

512 - NOT USED

513 - ACCESS DOORS

513.01 GENERAL

Access doors shall be installed in post tensioned box girders as located and as detailed on the Drawings.

All access doors shall be fabricated of steel shapes, plates and accessories conforming to, and all steel shall be galvanized in accordance with Section 12 (Metal Works) of these Specifications.

513.02 MEASUREMENT AND PAYMENT

513.02.1 Method of Measurement and Basis of Payment

The furnishing and installing of access doors as shown on the Drawings and specified herein will be paid for at the rate inserted in the Bills of Quantities for the number constructed and shall include for all labour, plant and materials and everything necessary for the furnishing and proper installation of the doors.

513.02.2 Items in the Bill of Quantities

PAY	ITEM DESCRIPTION	UNIT OF MEASUREMENT
513. 1	Access doors for box girder	nr.

514 - STRUCTURAL STEEL

514.01 GENERAL

Unless otherwise shown in the Contract Documents, all structural steel shall conform to the requirements of ASTM A 36, Section 12 (metal Works) of these Specifications and all welding shall be performed to the details shown in accordance with the American Welding Society Specifications by experienced welders as approved by the Engineer.

514.02 MEASUREMENT AND PAYMENT

514.02.1 Method of Measurement and Basis of Payment

The furnishing and installing of such structural steel incidental to concrete work as shown on the Drawings and specified herein will not be measured or paid for unless so specified herein but will be considered a subsidiary

obligation of the Contractor under the various items of work included in the Bills of Quantities for Section 5 (Concrete Works) of these Specifications.

515 - MISCELLANEOUS CONCRETE STRUCTURES

515.01 GENERAL

The work included herein provides for construction of miscellaneous concrete structures such as roadway median barriers, concrete headwalls, all in accordance with these Specifications, as shown and detailed in the Drawings, and as directed by the Engineer.

The Class of concrete to be used for each type of structure shall be as hereinbefore specified. Structure excavation and backfill shall meet the requirements of Section 2 (Earthwork) of these Specifications.

515.02 ROADWAY MEDIAN AND SIDE BARRIERS OFF STRUCTURES

515.02.1 General Roadway Requirements

Concrete roadway median and side barriers off structures shall be constructed as shown on the Drawings and as specified herein. Forms shall be smooth and tight fitting and of a type which can be held rigidly to line and grade during placing of concrete and which can be readily removed without damaging the concrete.

At the option of the Contractor, median and side barriers may be precast in sections not exceeding 6.0 metres. The method of casting, handling and placing barrier sections shall be as approved and directed by the Engineer.

Details of any reinforcement required in precast barriers to facilitate handling are to be prepared by the Contractor for the Engineer's approval.

Barrier expansion joints, as detailed on the Drawings, shall be placed at intervals not exceed 6.0 metres, except as directed by the Engineer. Preformed joint filler and sealer shall conform to the requirements for expansion joints as specified herein, and Styrofoam filler strips shall be detailed for precast barrier joints.

515.02.2 Measurement and Payment

515.02.2.1 Method of Measurement and Basis of Payment

Median and side barriers off structures shall be measured separately by metre run. Measurement of barriers on structures is not included in this section but is measured separately under the method of measurement and payment for general concrete. Payment shall be at the rate included in the Bills of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including excavation of tenches, grading of trench bottom, blinding where shown on the Drawings, upholding the slides of the trench, removal of surplus excavated material, backfilling, providing and fixing the barriers whether in situ or precast concrete with all necessary formwork, forming expansion joints as required, testing and all other incidental work in connection with the construction.

Payment for reinforcing steel if required in barriers will be considered included in the rates for median and side barrier off structures shown in the Bills of Quantities and no additional payment will be made.

515.02.2.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
515.1	Barrier (type)	m.

515.03 CONCRETE HEADWALLS

Headwalls shall not be constructed until the fill has been completed over the associated structure, unless otherwise directed by the Engineer.

Extreme care shall be used in excavating for headwall construction adjacent to and under the ends of culverts to avoid disturbance or damage to the pipes or box culvert structures.

Culverts damaged or disturbed by the Contractor's operations shall be removed and replaced at his own expense.

515.03.1 Measurement and Payment for Headwalls

Measurement and payment for headwalls shall be in accordance with Clause 610.03 of these Specifications.

516 - PROTECTIVE MEMBRANES

516.01 GENERAL

The following Specification covers the furnishing and applying of self-adhering waterproofing protective membrane to surfaces as shown on the Drawings or where directed by the Engineer.

The Contractor shall furnish the Engineer evidence that the personnel applying the material are qualified and manufacturer-approved.

Structures situated wholly or partly below the ground water level shall be protected by membrane. The membrane shall be extended 1 metre above the groundwater table. Protective membrane shall be used in all cases where structures are situated in contact with agricultural soil and shall extend to 100mm above the top level of the agricultural soil.

516.02 SUBMITTALS

The Contractor shall submit to the Engineer for approval three samples of each type of the following materials:

a. Self-adhering membrane waterproofing sheet, each sample size 300 mm by 300mm.

b. Bituminous mastic: Each sample size one litre.

c. Primer: Each sample size one litre.

Samples b, and c, shall be delivered in tightly sealed metal cans.

The Contractor shall submit to the Engineer certificates that materials to be furnished comply with Specification requirements.

516.03 PRODUCT DELIVERY, STORAGE AND HANDLING

The Contractor shall deliver products to the job site in their original unopened containers clearly labelled with the manufacturer's name, brand designation, type and class as applicable and the date of manufacture.

Products shall be stored in an approved dry area with roll goods laid flat, one pallet high, and protected from contact with soil and from exposure to the elements. Products shall be kept dry at all times.

Products shall be handled in a manner that will prevent breakage of the containers and/or damage to the products.

516.04 MATERIALS

516.04.1 Protective Membrane

Protective membrane shall be a self-adhering composite sheet membrane consisting of a rubberized asphalt compound coated to one side of a film made of polyethylene, PVC, polyester or other approved material. Waterproofing asphalt shall resist hydrostatic pressure as appropriate for surrounding conditions. As a minimum it shall conform to the requirements in ASTM D5385. Protective membrane shall be chemically resistant, providing effective external protection against aggressive soils, contaminated ground water, hydrocarbons in suspension, and other chemicals found in the surrounding environment. The composite membrane shall be manufactured specifically for the intended application, and the film alone shall have a tensile strength of 140 kg/cm2 as per ASTM D638.

Property	Standard	Value
Elongation Film	ASTM D638	Longitudinal 210 % Transverse 160 %
Tear resistance	ASTM D1004	Longitudinal 340 MPa Transverse 310 MPa
Adhesion to primed concrete	ASTM D1000	1.8 Mpa
Elongation compound	ASTM D1000	1.8 Mpa
Puncture resistance	ASTM E154	220 N over 65 mm
Water resistance	ASTM D570	After 24 h. 0.14 % After 35 d 0.95 %
Environmental resistance	ASTM D543	
Moisture vapour transmission rate	ASTM E96	0.3 g/m^2 24 h
Minimum thickness		1.5 mm

Table 516.04.1.1: Waterproof Membrane Property Requirements

516.04.2 Rubberized Mastic

Rubberized mastic shall be a special compound provided by the self-adhering membrane manufacturer, formulated for its intended use.

516.04.3 Primer

Primer shall be a special compound provided by the self-adhering membrane manufacturer, formulated for its intended use.

516.05 APPLICATION

516.05.1 General Procedures

a. Surfaces to which the waterproofing materials shall be applied shall be surface dry, smooth and free from dirt, grease and oil or other deleterious materials.

b. The Contractor shall co-ordinate the self-adhering waterproofing membrane work on the blinding slab so that the placement of a protection slab where specified will follow the waterproofing membrane application by not more than five days.

c. Application of primer materials may be by brush or roller. The primer shall be allowed to dry before the membrane sheet is applied.

d. The Contractor shall apply the membrane sheet with 120 mm overlaps at edges and ends, and the sheet shall be rolled down firmly and completely.

e. The Contractor shall follow the self-adhering membrane manufacturer's approved written recommendations for specific procedures, details and materials not specified herein.

f. If the work must be left partially complete, the exposed edges of outside strips of membrane shall be finished with a trowelled bead of mastic.

516.05.2 Application of Membrane to Concrete

a. Asphalt membrane waterproofing shall not be applied to any surface until the Contractor is prepared to follow its application with the placing of the backfill within a sufficiently short time that the waterproofing will not be damged as a result of exposure., The Contractor shall apply primer over the cleaned concrete surface to the extent shown on the Drawings and in accordance with the membrane

manufacturer's printed instructions. The surface shall be reprimed if not covered within the maximum 'open time' specified by the manufacturer for the prevailing ambient conditions.

b. After the primer has dried to the extent specified by the manufacturer, the Contractor shall apply the self-adhering membrane to the concrete without stretching, and with the polyethylene face out. The membrane shall be smoothed down with heavy hand pressure or a small roller. Edges and ends shall be lapped as specified.

c. The Contractor shall double inside and outside corners by using an initial strip of 300 mm wide membrane, centred along the axis of the corner. This strip shall be covered by the regular application of self-adhering membrane. A trowelled bead of mastic shall be applied over all exposed edges of the membrane.

d. The membrane on blinding slabs shall extend to the outer edge of the slab and shall be protected as specified below. Sidewall membrane shall extend down and out to the edge of the previously applied blinding slab membrane.

e. Areas around drains, piping and protrusions shall be double covered with an additional layer of self-adhering membrane for a minimum of 300 mm in each direction beyond the limits of the feature. The membrane edges shall be coated and the gap between the membrane and protrusions shall be filled with mastic.

f. At expansion joints, an additional ply of membrane 500 mm wide, centred on the joint and extending full width of the roadway and up to the membrane terminating point of the walls shall be applied.

516.05.3 Protection Layer

Before any work is allowed to proceed above a waterproof membrane, or within five days of its application whichever is the sooner, the membrane shall be protected by an approved protection layer as shown on the Drawings or as otherwise directed by the Engineer. The protection layer against vertical surfaces shall be protection board. Horizontal surfaces shall be protected by a sand/cement screed 50 mm thick or equivalent approved by the Engineer or as otherwise shown on the Drawings.

516.05.4 Repairs

The Contractor shall repair gouges and other damage to the completed membrane by means of membrane patches applied prior to placement of the protection layer.

516.05.5 Protection Board

Protection board shall be capable of protecting the underlying membrane from damage during backfilling and other construction operations. It shall be a non-rotting semi-rigid board composed of bitumen bound stone, felt, fiber or similar approved material. The protection board can be in a composite with the waterproof membrane. Protection boards shall be used in accordance with BS 8102:1990.

Boards as supplied shall be a minimum of 750 mm wide by 1500 mm long by 6 mm thick, manufactured from selected aggregates, bound in modified bitumen encased between two layers of strengthened asphalt paper. The bituminous material shall be a minimum of 1.5 mm thick and the membrane shall be capable of bridging crack widths in the substrate up to 0.6 mm wide.

516.05.6 Installation of Asphalt Protection Board

Within five days of membrane application, or before placing backfill against protected surfaces, whichever is the sooner, the Contractor shall install asphalt protection board to vertical and horizontal membrane-on-concrete surfaces where indicated on the Drawings. The board shall be stuck to the membrane by means of epoxy or other approved adhesive which will not damage the membrane. Protection board on blinding slabs shall terminate at the outer corner of the concrete structure above. Sidewall protection board shall extend down and out to cover the horizontal blinding slab membrane.

516.06 MEASUREMENT AND PAYMENT

516.06.1 Method of Measurement and Basis of Payment

Measurement of protective membrane shall be by the meter square of base to which the membrane is applied. Protective membrane fixed horizontally (or not exceeding 10 degrees from horizontal) and protective membrane fixed vertically (or exceeding 10 degrees from horizontal) shall be measured separately. Separate items shall be measured for protective membrane with protection layer and protective membrane with protection board.

Payment for protective membrane shall be at the rates inserted in the Bills of Quantities, which rate shall include all labour, plant, materials, equipment and everything necessary for the proper execution of this work including surface preparation, membrane, mastic, primer and protection layer or protection board and including laps and additional plies of membrane as specified.

516.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
516. 1	Protective membrane fixed horizontally (type of protection)	sq.m.
516. 2	Protective membrane fixed vertically (type of protection)	sq.m.

517 - PROTECTIVE PAINTING OF CONCRETE

517.01 GENERAL

The following Specification covers the furnishing and application of rubberised bitumen to buried surfaces of concrete as detailed on the Drawings. Protective painting shall be sovent-free, suitable for damp surfaces and resistant against soil acids, alkali and sulphate containing water

Two coats of bituminous protective painting shall be applied to all concrete surfaces in contact with soil and not protected by membrane. Protective painting shall be terminated at finished ground level.

517.02 SUBMITTALS

The Contractor shall submit to the Engineer for approval three samples in one litre containers of the rubber bitumen emulsion.

The Contractor shall submit to the Engineer certificates that the material to be furnished complies with Specification requirements.

517.03 MATERIALS

The rubber bitumen emulsion shall be a water bound emulsion with a minimum 60% total solids content by volume, comprising bitumen with fine particles of rubber. Not less than 10% nor more than 20% of the total solids shall be rubber. The consistency shall be such that it can be applied to the surface by brush at normal temperature.

517.04 APPLICATION

Before the application of rubberised bitumen emulsion the concrete surfaces shall be thoroughly cleaned and made free from dirt, dust, grease and other extraneous matter and lightly brush dampened immediately prior to application of the emulsion.

The surfaces to be treated shall be primed in accordance with the emulsion manufacturer’s instructions.

The second coat, consisting of undiluted emulsion, shall be applied as soon as the priming coat is dry, at the approximate rate of 9 litres per 15 m2.

The emulsion shall be applied by brush, squeegee or spraying strictly in accordance with the manufacturer's instructions. It shall not be applied during or when rain or dust storms are to be expected.

Backfilling shall not be commenced until the emulsion is quite dry.

517.05 MEASUREMENT AND PAYMENT

517.05.1 Method of Measurement and Basis of Payment

Measurement of protective painting of concrete shall be by the metre square of developed surface areas covered by the rubberised bitumen.

Payment for protective painting of concrete shall be at the rate inserted in the Bills of Quantities, which rate shall include all labour, plant materials, equipment and everything necessary for the proper execution of this work including surface preparation, emulsion etc.

517.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
517. 1	Protective painting of concrete (type)	sq.m.

SECTION 6: STORMWATER DRAINAGE

600 - SUPPLY OF PIPES

600.01 GENERAL

The Contractor shall be responsible for securing the required quantities of materials at the proper time for the work, and delay in the supply and/or delivery thereof shall not entitle the Contractor to make a claim for extension of the Contract period nor for any additional expenses on account of such delay.

The Contractor shall supply to the Engineer manufacturer's signed certificates stating that the pipes comply in all respects with the provisions of these Specifications.

600.02 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
A 123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A 153	Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
A 283M	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
	Standard Specification for Deformed and Plain
A 615M	Carbon-Steel Bars for Concrete Reinforcement
A 709M	Standard Specification for Structural Steel for Bridges
C 14M-07	Standard Specification for Non Reinforced Concrete Sewer, Storm Drain and Culvert Pipe (metric)
C 76M	Reinforced Concrete Culvert, Storm Drain and Sewer Pipe
C 131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C 150	Standard Specifications for Portland Cement
C 207	Hydrated Lime for Masonry Purpose
C 301	Test Method for Vitrified Clay Pipes
C 425	Compression Joints for Vitrified Clay Pipe and Fittings
C 443 M	Joints for Circular Concrete Sewer and Culvert Pipe Using Rubber Gaskets (Metric)
C 478	Precast Reinforced Concrete Manhole Section
C 494	Standard Specification for Chemical Admixtures
C 618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C 700	Vitrified Clay Pipe, Extra Strength, Standard Strength and Perforated
C 869	Standard Specification for Foaming Agent Used in Making Performed Foam for Cellular Concrete
C 989	Standard Specification for Slag Cement for Use in Concrete and Mortars
C 1208M	Standard Specification for Vitrified Clay Pipe and Joints for Use in Microtunneling, Sliplining, Pipe Bursting, and Tunnels
D 41	Standard Specification for Asphalt Primer Used in Roofing, Damp Proofing and Waterproofing.
D 412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
D 449	Standard Specification for Asphalt Used in Damp proofing and Waterproofing
D 570	Standards Test Method for Water Absorption of Plastics
D 638	Standard Test Method for Tensile Properties of Plastics
D 1004	Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
D 2657	Standard Practice for Heat Fusion of Polyolefin Pipe and Fittings
D 2774	Standard Practice for Underground Installation of Thermoplastic Pressure Piping
D 2837-98A	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials
D 3212	Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
D 3350-99	Standard Specifications for Polyethylene Plastic Pipe and Fittings Materials
D 4354	Standard Practice for Sampling of Geosynthetics for Testing
D 4873	Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
F 585	Practice for Insertion or Flexible Polyethylene Pipe into Existing Sewers.
F 714	Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on outside Diameter
F 894- 95	Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.
F 1055	Standard Specification for Electro Fusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
F 1417	Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
F 1668	Standard Guide for Construction procedures for Buried Plastic Pipe

DIN **DEUTSCHES INSTITUT FUR NORMUNG**

DIN 8074	HDPE Pipe Dimensions
DIN V 1201	Concrete Pipes and Fittings, Unreinforced, Steel Fibre and Reinforcement for Drains and Sewers-Type 1 and Type 2
DIN EN 1916	Concrete Pipes and Fittings, Unreinforced, Steel Fibre and Reinforced
DIN 16961-1	Thermoplastics Pipes and Fittings with Profiled Wall and Smooth Pipe Inside - Part 1: Dimensions (DRAFT)
DIN 54815-1	Pipes Made of Filled Polyester Resin Moulding Materials - Dimensions, Material and Marking

WIS **WATER INDUSTRY STANDARDS**

WIS4-35-01	Specification for Thermoplastics Structured Wall Pipes, Joints and Couplers with a Smooth Bore for Gravity Sewers for the Size Range 150-900 Inclusive.

EN **EURO NORM**

prEn 13476-1	Plastics Piping Systems for Non-Pressure Underground Drainage and Sewerage-Structured Wall Piping Systems of Unplasticized Poly (Vinyl Chloride) (PVC-U), Polypropylene (PP) and Polyethylene (PE).
EN 744	Plastics Piping and Ducting Systems - Thermoplastics Pipes - Test Method for Resistance to External Blows by the Round-the- Clock Method

AASHTO **AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTAION OFFICIALS**

AASHTO	LRFD Bridge Design Specifications.
M 86M/M86 (2009)	Standard Specification for Nonreinforced Concrete Sewer, Storm Drain and Culvert Pipe
M 145	Classification of Soil and Soil-Aggregate Mixture for Highway Construction Purposes
M 294 M	Corrugated Polyethylene Pipe 300 – 1200 Diameter.
T 180	Moisture Density Relations of Soils Using a 10 1b (4.54 kg) Rammer

BS	**BRITISH STANDARD**
BS 4	Structural Steel Sections
BS EN 124	Gully Tops and Manhole Tops for Vehicular and Pedestrian Areas.
BS EN 206-1	Concrete, Specification, Performance, Production and Conformity
BS EN 295-7	Vitrified Clay Pipes and Fittings and Pipe Joints for Drains and Sewers. Requirements for Vitrified Clay Pipes and Joints for Pipe Jacking
BS 449	The Use of Structural Steel in Buildings
BS EN 499	Covered Electrodes for Manual Metal Arc Welding of Non Alloy Fine Grain Steels
BS EN 598	Ductile Iron Pipes, Fittings, Accessories and Their joints for Sewerage Applications. Requirements and Test Methods
BS 812	Testing Aggregates
BS 882	Aggregates From Natural Sources for Concrete
BS 916	Black Bolts, Screws and Nuts
BS EN 969	Ductile Iron Pipes and Fittings
PD 970	Parts 1-6 Wrought Steels in The Form of Blooms, Billets and Forgings
BS EN 1011-2	Metal-Arc Welding of Carbon and Carbon Manganese Steels
BS EN 1401-1	Plastic Piping Systems for Non-Pressure Underground Drainage and Sewerage-Specification for Unplasticised PVC Pipe, Fittings and the System.
BS EN ISO 1461	Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles –Specifications and Test Methods
BS EN 1561	Grey Iron Castings
BS EN 1768	Unified Precision Hexagon Bolts, Screws and Nuts (UNC And UNF) Normal Series
BS EN 1916	Concrete Pipes and Fittings, Unreinforced, Steel Fibre and Reinforced
BS 3148	Water for Making Concrete
BS 3416	Black Bitumen Coating Solutions for Cold Application
BS 3506	Unplasticised PVC Pipe for Industrial Purpose
BS 4211	Specifications for Permanently Fixed Ladders
BS ISO 4427-2	Plastics Piping Systems —Polyethylene (PE) Pipes and Fittings for Water Supply — Part 2: Pipes
BS 4449	Carbon Steel Bars for Reinforcement of Concrete
BS 4622	Grey Iron Pipes and Fittings
BS 4872	Approval of Testing of Welders Part 1. Fusion Welding of Steel
BS 4962	Performance Requirements for Plastic Pipe for Use AS Light Duty Sub-Soil Drains
BS 5075	Concrete Admixtures
BS 5493	Code of Practice for Protective Coating of Iron and Steel Structures Against Corrosion
BS 5911-1	Specification for Unreinforced and Reinforced Concrete Pipes
BS 6349	Code of Practice for Maritime Structures
BS 7668	Weldable Structural Steels
BS 7874	Standard Specification for Elastomeric Seals for Joints in Pipework and Pipelines
BS 8500-2	Specification for Constituent Materials and Concrete
BS EN 12350	Testing Fresh Concrete. Slump - Test
BS EN 13101	Manhole Step Irons (Malleable Cast Iron)
BS EN 14396	Fixed Ladders for Manholes
BS EN 60085	Classification of Insulating Materials for Electrical Machinery and Apparatus on the Basis of Thermal Stability in Service

AWWA	**AMERICAN WATER WORKS ASSOCIATION**
C 104	American National Standard for Cement Water Lining for Ductile, Iron and Grey Iron Pipes
C 213	and Fittings for Water Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines

ISO	**INTERNATIONAL ORGANIZATION FOR STANDARDIZATION**
ISO 1083	Spheroidal Graphite Cast Irons Classification-Third Edition.
ISO 4427	Polyethylene (PE) Pipes and Fitting for Water Supply
EN ISO 9969	Thermoplastics Pipes - Determination of Ring Stiffness
BRE	
BRE	Special Concrete in Aggressive Ground Digest 1:2005
CIRIA	**CONSTRCUTION INDUSTRY RESEARCH AND INFORMATION ASSOCIATION**
CIRIA (SP 83)	A Guide to Managing Costal Erosion in Beach /Dune System
ISRM	**INTERNATIONAL SOCIETY FOR ROCK MECHANICS**
ISRM-1986	Report on ISRM Fields of Activities

600.03 SHOP DRAWINGS

The Contractor shall prepare shop drawings for all new stormwater drainage work in accordance with the requirements of the Contract Drawings and Specifications. Such shop drawings shall be submitted to the Engineer for his review, comments and approval and shall be prepared and submitted in accordance with the requirements of, Materials and Manufactured Goods. Such submittals shall also include, but not by way of limitation, the following, even though items proposed to be furnished comply with the exact descriptions as stated in these Specifications.

a. Full details of pipe, fittings, joints and the assembly thereof. The weight of all pipe and fittings shall also be stated.
b. Jointing materials, gaskets and details.
c. Liner materials and details.
d. Pipe laying diagrams showing location, length, design and number designation for each pipe section and pipe special to be installed.
e. Reinforcement steel drawings of variously sized pipe cage assemblies.
f. Pipe supplier's storing, handling, installation and testing instruction catalogue(s).
g. Manufacturers' Certifications of Compliance with these Specifications for all pipe products.
h. Structural details for bases, GRP liners, riser or barrel sections, adjustment rings, top slabs and steps/ladders.
i. Reinforcement steel bending and setting drawings for all structures and protection slabs.
j. Catalogues and full details of all castings and metal works.
k. Catalogues and specification for all protective coatings, liners and sealants.

Shop drawings by the Contractor for the stormwater drainage system works shall not be considered complete until the locations of all existing underground utilities have been determined by manual excavation as specified in Section 2 (Earthworks), Manual Excavation, of these Specifications and on the basis of the most recent information available from all local utility agencies or their designated consultants.
The shop drawings shall include the details and locations of all existing utilities as determined by manual excavation. The Contractor shall determine the locations of interference, if any, between existing underground utilities and the stormwater drainage system works to be constructed under the Contract. Where any interference is identified, the Contractor shall prepare an alternative method of construction for approval of the Engineer to avoid the interference. The alternatives to be prepared by the Contractor in these cases shall consider the relocation of the interfering existing utility or modification of the design for the stormwater drainage system works or a combination of both.

Shop drawings for stormwater drainage system works shall include details of protection works for existing utilities to be furnished, installed, maintained and removed by the Contractor as required for the installation of the stormwater drainage system works.

600.04 PRIORITY IN WORK COMMENCEMENT

The Contractor shall observe the following in executing the Stormwater Drainage works:

a. Before proceeding with storm water drainage works, the Contractor shall complete manual excavations to determine the existence and locations of existing underground utilities; and the Contractor shall prepare shop drawings and proposed material submittals for the approval of the Engineer all in accordance with Section 1(General), Submittals, Section 2 (Earthworks), Manual Excavation, and Clause 600.03 Shop Drawings, of these Specifications.

b. The installation of stormwater drainage works shall be completed prior to construction of base courses, pavement, curbs or related works. The Contractor shall comply with the requirements of Work Program, of the General conditions of Contract by submitting an approved written program clearly indicating that the installation of the stormwater drainage works shall precede the construction of the roadway. Further, the installation of the stormwater drainage works shall be in such a sequence as not to interfere with or interrupt other works under separate contracts awarded by MPW.

c. The Contractor shall maintain flow in all existing stormwater drainage lines which may be affected by work under this Section. Flow shall be maintained by means of by-passes or pumping as designed by the Contractor with sufficient capacity to carry the maximum flow without restricting the flow in the existing stormwater drainage lines.

d. The Contractor shall not commence connecting the new stormwater drainage system, to existing stormwater drainage installations before laying, jointing cleaning, testing and Engineer`s approval of the new facilities unless otherwise directed by the Engineer.

600.05 WATER TIGHTNESS AND TESTING –

600.05.01 General

It is imperative that all pipelines, manholes, junction chambers, catch basins, inlets, dewatering duct end structures, plugs, caps and joints are as watertight as possible, not to exceed the maximum exfiltration or infiltration rates otherwise specified herein.

Regular inspections will be undertaken by the Engineer on all completed Works for signs of infiltration or exfiltration. The Contractor must devise means of accurately measuring the rate of infiltration or exfiltration by performing measurements in the presence of the Engineer strictly in accordance with the standards and as directed by the Engineer.

601 - HIGH DENSITY POLYETHYLENE (HDPE) PIPES AND FITTINGS

601.01 GENERAL

This Specification covers the design, furnishing and installation of all High Density Polyethylene (HDPE) pipe for culverts, drains and conduits together with all necessary fittings, couplings and jointing systems.

HDPE pipes shall be installed by open cut methods only.

All specifications, standards, or codes applicable, mentioned or brought in by reference shall be the latest edition of those documents.

Before these Specifications are used on any particular project, the Engineer shall review them for suitability for use.

601.02 DEFINITIONS

a. The following definitions shall apply to words or phrases used in this section:

   1. E' – Modulus of soil reaction.
   2. LRFD – Load Resistance Factor Design.

b. 1. Profile wall shall mean a pipe wall construction that presents an essentially smooth surface in the water way but including ribs or other shapes which can be either solid or hollow that help brace the pipe against diametrical deformation.
   2. "Pipe Specials" shall mean unusual fittings or bends not covered by recognized manufacturing standards.

c. Electrofusion welding – The thermal welding of a pipe joint by the melting of the HDPE in the walls of a spigot and bell joint by application of a controlled electric current to factory-embedded electrical resistance wires in the bell.

601.03 DESIGN

Design shall be to the latest edition and addendums to 'AASHTO LRFD Design Specifications, Section 12 – 'Buried Structures and Tunnel Liners'.

Design to be based on 50 year mechanical properties.

The correct performance of the pipe at the designed depth, groundwater level, and soil conditions depends on the installation reaching the design E' value for the pipe embedment, and on the pipe being installed in accordance with ASTM D 2321, ASTM F 1668, and the manufacturer's recommendations. The Engineer shall ensure that all of these conditions are applicable, can be met and that design values of E' can be, and are, achieved on site with the prevailing materials for embedment, backfill and natural soil conditions.

601.04 MATERIALS

Unless specified elsewhere on the Drawings or Particular Specifications, HDPE pipes and fittings shall conform to the following:

a. For gravity systems or smooth-bore culverts,

   1. 250 – 300mm diameter:

      HDPE pipes and fittings shall meet the requirements of ASTM F 894 and Section 12 of AASHTO LRFD Bridge Design Specifications – 50 year mechanical property requirements.

   2. 350 – 1200mm diameter:

      HDPE pipes and fittings shall meet the requirements of AASHTO M 294-M, Corrugated polyethylene pipe, 350-1200 Diameter – type D or type S, and Section 12 of AASHTO LRFD Bridge Design Specifications – 50 year mechanical property requirements.

b. For pressure systems,

   1. 90mm to 1200mm diameter:

      HDPE pipes and fittings shall meet the requirements of ASTM F 714 and Section 12 of AASHTO LRFD Bridge Design Specifications – 50 year mechanical property requirements.

c. For corrugated culverts only,

   1. 300mm to 1200mm diameter:

      HDPE pipe shall meet the requirements of AASHTO M294-M, Corrugated Polyethylene Pipe 300-1200mm diameter - Type C, and Section 12 of AASHTO LRFD Bridge Design Specifications – 50 year mechanical property requirements.

      Except that:

   1. The range of internal diameters of pipes shall also include those given in Table 2 of DIN Standard 16961-1 up to 3000mm diameter.

   2. The brittleness test in AASHTO M 294 shall be replaced by the impact test from EN744 carried out at 0^{o}C.

d. All PE compounds, irrespective of the standard or class of pipe, shall meet the Environmental Stress Crack Resistance requirements of AASHTO M 294 (SP-NCTL) test.

e. The minimum section properties shall be as in Section 12 of AASHTO LRFD Bridge Design Specifications, 'Buried Structures and Tunnel Liners' except that where pressure pipe is used for non-

pressure applications, the minimum SDR shall be used and manufacture shall be to the designated pressure class unless otherwise approved by the Engineer.

f. Pipes shall be supplied and designed for sustained operating temperatures of 450°C. Any short-term or long-term change in the mechanical properties of the HDPE resin at this temperature shall be taken into account in the design.

g. Any special fittings for pipework shall be obtained from the pipe manufacturer, unless otherwise approved by the Engineer.

h. Pipes and Fittings manufactured in Kuwait to any other relevant standard will be accepted under this Specification provided that the pipe manufacturer warrants that the pipes meet or exceed the requirements of this Specification in every respect and that the manufacturer certifies in writing that this is the case. If required by the Engineer, the manufacturer shall carry out or have carried out at the manufacturer's expense such tests as may be required in order to demonstrate compliance with this Specification. Pipes of any standard that are not manufactured in Kuwait shall be subject to such testing,

i. All HDPE pipes shall be properly marked as required by the relevant Standards, with the following information as a minimum:

1. Manufacturer's name or distinctive mark.
2. Date of manufacture.
3. Class or pressure rating (if applicable).
4. Nominal diameter.
5. Standard of production (e.g. ASTM F 894-98a) (Note: this shall be the actual standard of production – not the standard that the pipes are accepted as meeting.).
6. The angle of bends or branches.
7. Where appropriate, individual reference number.
8. Number and mark of independent testing agency (if applicable).

j. SDR is the Standard Dimension Ratio, which is defined as the ratio of pipe diameter (measured at mid point of wall) to pipe wall thickness.

k. HDPE Gravity Drainage Pipes may be Solid Wall or Profile Wall.

l. Contractor shall submit calculations covering the soil pressure on the buried pipe and restraint of expansion or contraction. Restraint anchors shall be provided if required. Manholes may be regarded as such restraint blocks, provided that they can be shown to provide the necessary resistance.

m. Where pressure pipe is designated for non-pressure applications, the minimum SDR shall be supplied and manufacturing shall conform to the designated pressure class, unless otherwise approved by the Engineer.

n. Pipe lengths shall be in accordance with the manufacturer's recommendations as approved by the Eengineer.

o. When pipe lengths greater than 6 metres are supplied the socket depths shall be greater than a mln specified in prEN 13476-1 Table 6.

p. The Contractor shall provide the proper equipment and slings necessary to handle the length of pipe being used.

q. Pipe bedding and pipe surround shall be as indicated on the Contract Drawings.

r. HDPE pipes shall have a minimum Ring Stiffness of 8KN/M2 as tested per ISO 9969 for 900mm pipe diameter or smaller.

A minimum Ring Stiffness of 4 kN/ m^2 may be considered for only HDPE pipe larger than 900 mm diameter.

s. The Contractor shall submit for approval all necessary documentations and calculations demonstrating compliance with pipe deflection requirements.

t. The pipe bedding and surround shall be Class 1A granular material in accordance with ASTM D 2321.

u. Cement / sand mix for the pipe bedding and surround will be considered if carried out in accordance with ASTM D 2321 along with the following conditions.

1. The Contractor shall utilize an approved internal vibrator (Rerounder) to compact and consolidate the pipe surround and insure pipe roundness after completing the pipe installation and backfilling operations. The initial deflection shall not exceed 1% after completing the backfilling operations.

2. The Contractor shall submit for approval a method statement for backfilling operations and internal vibration including details of equipment to be used. The method statement shall demonstrate compliance with manufacturer's specifications for internal vibrator and allow for testing compaction of each lift on all backfilling operations.

v. Elastomeric sealing rings (Rubber gaskets) shall be made from EPDM.

w. Pipe sizes shall be as shown on the Drawings, unless otherwise approved by the Engineer.

x. The designated sizes on the Drawings refer to nominal internal diameters for both Solid Wall Pipes and Corrugated Twin Wall Pipes.

1. Solid Wall Pipes shall have a SDR of 18 or better.

2. Profile Wall Pipes shall have an effective SDR of 18 or better.

601.04.1 HDPE Base Resin Material Specification

a. The base resin shall have a cell classification according to ASTM D 3350 for pipes and injection molded fittings as follows. The selected resin shall also be able of meeting all other requirements within this Specification. Compounds that have a higher cell classification in one or more properties shall be acceptable provided the other product requirements are met.

	Property	**Cell Class**
1	Resin Density	3
2	Melt Index	3
3	Flexural Modulus	5
4	Tensile Strength	4
5	ECSR	4
6	HDB	NPR
7	Color & UV Code	C
Legend:1 – Minimum Carbon black content shall be between 2-3%		

b. The resin shall also meet the following requirements. The test shall be carried out in the form of a Solid Wall Pipe made from the relevant extrusion.

PROPERTY	**UNIT**	**VALUE**	**STANDARD**
			ISO
Resistance to internal pressure 80^0C water in water hoop stress tested to 165 hours	MPa	3.9	4427
Resistance to internal pressure 80^0C water in water hoop stress tested to 1000 hours	MPa	2.8	4427

601.04.2 Submittals

A. All pipes and fittings shall be submitted for approval.

B. Different sizes and types of pipes and fittings, even if from the same manufacturer, shall be placed in separate submittals.

C. The manufacturer shall provide proof of successful past use of the proposed pipes and fittings on work of a similar environment and scope of that for this Project.

D. As a minimum, the submittal should include the following:

1. The Contractor shall develop and submit a Method Statement. “Installation, Quality Control, Inspection and Testing" to cover all aspects of installation of HDPE Pipes and Fittings.

2. Product Data: Manufacturer's specifications and installation instructions. Test results that show compliance with the Contract Documents.

3. Shop Drawings: Detailed shop drawings shall be submitted to the Engineer for approval. These shall show all relevant details including:

    a. Connections at manholes.

    b. Joining to existing mains.

    c. Couplings and Thrust Blocks.

    d. Contractor shall furnish the Engineer with samples of the proposed connection between the pipe and manhole lining when used with lined concrete manholes and provide testing as required by the Engineer.

    e. Joint details.

4. Samples: One sample of each type.

601.04.3 Quality Assurance

A. Prior to dispatch from the factory, the Contractor shall notify the Engineer in sufficient time to allow the Engineer, or his representative, to inspect the pipes and fittings, if so desired.

1. All notifications shall be made by written Inspection Requests.

    An advance copy may be faxed to the Engineer's office, but the original must be submitted before the scheduled day of inspection.

2. Minimum notification times shall be as follows:

    a. 24 hours on site.
    b. 72 hours for areas within Kuwait.
    c. 3 weeks outside of Kuwait.

601.04.4 Delivery, Storage and Handling

A. Pipes, fittings and specials shall be delivered, handled and stored according to the manufacturer's recommendations along with the following provisions:

1. Transportation, handing and storage shall at all times be performed in a manner to avoid product damage.

2. Only nylon slings shall be allowed for lifting pipes and fittings. Steel chains, clamps or cables shall not be allowed for lifting purposes.

    a. Nylon slings shall be used for securing pipes during transport and storage.

b. Pipes shall be unloaded from trucks by crane. Under no circumstances shall pipes be tipped onto the ground.

3. Do not store pipes on rough or rocky ground.

4. Pipes shall be stored under a shade, in such a manner as to allow air to circulate freely among the pipes and thereby avoid excessive build up of heat in the pipes.

5. Visually inspect all pipes upon delivery and report any damage to the Engineer.

   a. Any pipes damaged during delivery, storage or installation shall be marked and set side.

   b. Proposals for repair of any damaged pipes shall be submitted in writing to the Engineer for approval.

   c. No repairs to damaged pipes shall be attempted without the Engineer's approval.

   d. Any damaged pipes deemed unsuitable for repair by the Engineer shall be removed from Site and replaced at the Contractors expense.

6. Elastomeric sealing rings (rubber gaskets) shall be stored in closed containers out of direct sunlight, until needed.

601.05 JOINTS

Jointing of non-pressure pipes shall be in accordance with Clause 4.3 of ASTM F 894 and ASTM D3212. Extrusion welding on bell and spigot joints shall be carried out to both inner and outer walls of the pipe as shown in figure 2 of Clause 4.3 of ASTM F 894 except that the inner weld will not be required on pipes of less than 800 diameter. Alternatively, electrofusion jointing of pipes to ASTM F 1055, or equal quality, may be permitted subject to the pipe manufacturer producing documentary evidence of successful use of this method on his pipes in the past.

The pipe system shall also include a double socket type HDPE elastomeric joint seal coupling to ASTM D 3212 that can be used at any location along a pipe barrel.

Joints shall be watertight when tested in accordance with ASTM D 3212.

Any elastomeric joint seals used shall be supplied by the pipe manufacturer.

HDPE pressure pipes to ASTM F 714 shall be joined by butt fusion to ASTM D 2657 or by approved mechanical couplings which shall be supplied by the pipe manufacturer. Parameters for butt fusion welding shall be agreed between the pipe manufacturer and the Engineer before work starts. Completed butt fusion welds shall show a raised bead on the inner and outer surfaces of the welded pipe.

601.06 INSTALLATION

a. Unless specified elsewhere in the Contract Documents, installation of HDPE pipes shall conform to ASTM D 2321 as supplemented by ASTM F 1668 and the manufacturer’s instructions. ASTM D 2774 shall be used only for general guidance on the installation of HDPE pressure pipes. Any embedment material used shall be checked for migration of fines either into or out of the material and, if required, an approved geotextile shall be provided around the embedment.

b. Trench excavation and backfill shall comply with Section 2 (Earthworks) of these Specifications, unless this is at variance with the requirements set out above in which case the latter shall take precedence.

c. Haunching and initial backfilling shall be carried out immediately after pipe has been placed in the trench.

d. Pipes shall be checked by laser, sight rails or string line, for grade and level at the ends of each pipe and at intervals not greater than 4 metres.

e. Where HDPE corrugated pipes are embedded in manhole walls, the minimum embedded length of pipe shall be 2 X corrugation pitch or the lengths given in the table below, whichever is the greater. A Hydrophilic sealing ring shall be placed around the pipe within the manhole wall, to ensure a watertight seal.

Normal Pipe Diameter(mm)	Minimum Embedded Length in box out (mm) (in addition to wall thickness)
200	200
250	200
300	200
350	200
400	200
500	200
600	200
700	200
800 -1200	265

f. Pipes laid with 600mm or less cover shall have concrete Class K 180 embedment. The concrete embedment shall incorporate a movement joint at each pipe joint location. This joint shall consist of a 25mm thick compressible filler board extending through the whole area of the concrete. When concrete embedment is used, any annular gap around a joint shall be filled with an approved compressible foam filler strip to prevent grout penetration into the gap around the pipe circumference. Concrete embedment shall be placed in such a manner that will prevent flotation or movement of the pipe. Concrete shall be placed against the undisturbed sides and bottom of the trench, shall be properly cured, and no backfill shall be placed on top of the concrete until at least eight hours after placing. If asphalt is to be placed directly onto the surface of the concrete, the surface of the concrete shall be textured with a heavy broom whilst still wet.

g. Pipes shall be laid to the lines and levels established by the Engineer.

601.06.1 Pipe Bedding / Surround

a. Pipe bedding and pipe surround shall be strictly in accordance with ASTM D 2321-"Underground Installation of Thermoplastic Pipe for Drainage pipes and Other Gravity Flow Applications".

1. The backfilling details are shown on the Typical Drawings.

2. All bedding, haunching and backfilling materials shall be placed in accordance with ASTM D 2321.

3. For normal natural soil condition in pipe bedding, the bedding, haunching and pipe surround shall be cement stabilized sand mix.

   Cement stabilized sand mix shall be used only for depths between 1.2 m and 6.0 m. The sand shall be clean durable well-graded sand. The mix shall be compacted to a minimum of 90% M.D.D. with moisture content between 0 to 2% above Optimum Moisture Content in the pipe zone. The cement sand ratio shall be 3% by weight.

4. For unsuitable soil conditions in the pipe bedding area, only Class IA granular materials shall be used in accordance with the typical Drawings and these Specifications. Unsuitable materials shall be as defined in Clause 201.01 of Section 2 (Earthworks) of these Specifications and Particular Specifications. Class IA granular material shall be compacted to a minimum of 90% M.D.D. and a geotextile fabric shall be provided around the granular pipe surround. The geotextile fabric shall comply with Section 2 (Earthworks) of these Specifications.

5. Where cover to the pipe is less than 1.2 meter and greater than 6.0 meter, the pipe shall be encased in Class k180 concrete in accordance with these Specifications.

6. Where pipes are to be laid beneath secondary roads and material other than Class IA, (ASTM D2321) is to be used from top of the pipe surround up to the road subgrade. The backfill up to the road subgrade shall be compacted to a minimum 95% M.D.D.

602 - CONCRETE PIPES

602.01 GENERAL

602.01.1 Material Specifications

The materials, manufacture, physical requirements, dimensional variations, workmanship and finish for the manufacture of pipes shall meet the requirements of BS 5911-1.

602.01.2 Approval to Source of Materials

The Engineer shall approve the sources of materials for pipe manufacture and shall supervise the necessary tests on representative samples to ascertain their compliance with the Specifications prior to their use on Site. All tests shall be performed by or under the supervision of the Engineer and at the Contractor's expense.

602.01.3 Securing Of Materials

The Contractor shall be solely responsible for securing all pipes and fittings required for the Contract regarding quantity, type and quality from any source unless otherwise specified, and the Employer does not guarantee the availability of such materials on the local market.

602.02 CEMENT

All cement used for the manufacturing of concrete pipes shall be of a fresh and approved quality Portland sulphate resisting cement Type V, complying with the requirements of ASTM C 150.

602.03 CONCRETE PIPES

602.03.1 General

Reinforced and unreinforced concrete pipes shall be of sound manufacture.

602.03.2 Unreinforced Concrete Pipes

Unreinforced concrete pipes shall generally conform to BS 5911-1 and BS EN 1916 or AASHTO M86M/M86, DIN V 1201 or ASTM C14M spigot and socket type except in respect of internal diameter, minimum crushing strength and internal dimensional tolerances.

The crushing test loads in kN/linear metre of effective length when tested in accordance with BS 5911-1 and BS EN 1916 shall be as given in Table 601.03.2.

Nominal Internal Diameter of Pipe (mm)	Maximum Load (kN/linear metre)
250	35
300	39
350	44
400	48
450	54
500	60
600	72

Table 601.03.2 – Crushing Strength of Unreinforced Pipes

602.03.3 Reinforced Concrete Pipes

Reinforced concrete pipes shall generally conform to BS 5911-1 and BS EN 1916 or ASTM C76M Class IV or DIN V 1201 and DIN EN 1916 except in respect of internal diameters, minimum crushing strength and internal dimensional tolerances. Unless otherwise agreed with the Engineer, pipes up to and including 1400mm internal

diameter shall be of the spigot and socket joint type and pipes with internal diameters in excess of 1400mm shall be of the rebated socket joint type.

The crushing test loads in kN/linear metre of effective length when tested in accordance with BS 5911-1 and BS EN 1916 shall be as given in Table 601.03.3.

Nominal Internal Diameter of Pipe (mm)	Maximum Load (kN/linear metre)
700	84
800	96
900	108
1000	120
1200	144
1400	168
1600	192
1800	216
2000	240

Table 602.03.3 – Crushing Test Loads of Reinforced Concrete Pipes

602.03.4 Minimum Crushing Test Requirements

If the minimum crushing test requirements are not satisfactory and only then, with the approval of the Engineer, the pipes shall then be protected by encasing them in Class K 180 concrete in accordance with Section 5 (Concrete Works) of these Specifications and the Engineer's instructions. The thickness of concrete encasement shall be sufficient to obtain the same minimum crushing strength requirements but shall not be less than 150mm. No additional payment shall be made in lieu of this work other than that for the pipes at the rates indicated in the Bills of Quantities. The Contractor shall not be entitled to claim for an extension of time with respect to this work.

602.04 MARKING

All pipes and fittings shall be marked indelibly after manufacture. The markings shall include:

a. Name of manufacturer.

b. Date of manufacture and serial number.

c. Nominal diameter.

602.05 DIMENSIONS

Nominal diameters shall refer to internal diameters of pipes.

602.06 TOLERANCES

The tolerances of the nominal diameter of pipes shall be ±5mm for 250 to 500mm nominal diameter, ±10mm for 600 to 1000mm nominal diameter and ±15mm for 1200 to 2000mm nominal diameter.

The tolerance on the length of an individual pipe shall be ± 20mm. The checking of dimensions and tolerances shall be done with special gauges approved by the Engineer, to be supplied by and at the expense of the Contractor.

603 - TESTING OF CONCRETE PIPES AT PLACE OF MANUFACTURE

All pipes shall be tested and certified in accordance with the requirements of the Standard according to which they were manufactured. All rejected pipes shall be promptly stamped “Rejected” in a conspicuous location on the pipe.

604 - DUCTILE AND CAST IRON AND STEELWORK

604.01 GENERAL REQUIREMENTS

Bolts, nuts shall be as shown and specified on the Drawings. All bolts and nuts for new work shall be metric series. Replacements for existing bolts may comply with BS 916 or BS 1768, as necessary.

Welding shall be carried out by approved welders in accordance with the requirements of the latest applicable ANSI / AASHTO / AWS Codes. Weld sizes, locations, and specific requirements shall be as shown on the Drawings.

Where otherwise shown on the Drawings or directed by the Engineer all steelwork shall be galvanized in accordance with ASTM A 123 or ASTM A 153. Where galvanizing or other protection is not specified steelwork shall be rust protected as follows:

After fabrication all rust, scale and loose paint shall be entirely removed by means of sand blasting or, with the permission of the Engineer, by steel wire brushes or other approved means.

All surfaces shall immediately thereafter be coated with two coats of an approved bituminous paint applied in accordance with the manufacturer’s instructions.

604.02 JOINTS

All pipes and fittings shall be furnished with self-aligning, flexible spigot and socket joints unless otherwise shown on the Drawings.

604.03 DUCTILE IRON MANHOLE COVERS AND FRAMES AND DUCTILE OR GALVANIZED STEEL GULLY GRATINGS (HINGED TYPE)

a. Standard manhole covers and frames shall be manufactured and tested according to BS EN 124, unless stated otherwise herein, or unless otherwise approved by the Engineer. Test Load shall be 400 kN heavy duty covers shall be made of ductile iron complying with ISO 1083 Grade SG 500-7.

b. All covers and frame for "storm water manhole" shall be hinged type single piece.

c. Covers shall have machined surfaces, to prevent rocking due to traffic with logo "Storm water Drainage" (both in English and Arabic). Logo shall also include "Name and Number of the Contract" (in Arabic only).

d. Heavy duty covers shall be hinged to the frame. The hinge system shall comply with MPW typical Drawings.

e. Drainage products may be produced from grey iron and shall be hard wearing, inherently stable and highly resistant to flexing.

f. During installation the frames shall be properly bedded and levelled to prevent rocking or any lateral movement of the frame.

g. Covers and frames shall be kept together as supplied unit and interchangeability between various covers and frames shall not be permitted.

h. All castings shall be supplied with a black epoxy coating finish.

i. The tops of all manhole covers shall have a non-slip surface to provide adequate grip.

j. When so designated, the supplier shall arrange for specific lettering to be cast into the top of the covers. The lettering shall be up to a maximum of 4 letters or digits.

k. All manholes covers and gullies supplied shall have been verified as being manufactured to BS EN 124 by third party assessment body for both quality procedures and technical requirements.

l. The manholes covers or gullies shall meet one of the loading categories specified in BS EN 124.

Loading Categories for Manhole Covers on Gullies

Class	Loading, Tonnes
A 15	1.5
B 125	12.5
C 250	25
D 400	40

m. For manhole entry a minimum 600mm clear opening shall be provided.

n. For manholes situated in the carriageway a three point cover seating shall be adopted to prevent any movement or rocking.

o. Where hinged gully gratings are installed the edge with a hinge shall face the traffic to ensure the cover closes if inadvertently left opened and hit by traffic.

p. Coatings:

All castings shall be locally coated by an approved applicator under the Engineer's supervision.

1. All covers and frames shall be grit blasted to Sa 2.5 (near white metal) condition.

2. Coating shall be solvent free polyamine epoxy, applied in 2 coats.

3. Nominal dry film thickness shall be 400 microns (total), with no more than 10% of the thickness readings less than 400 microns and no single reading less than 300 microns.

604.04 GRATINGS, FRAMES AND RUBBING STRIPS

Galvanised fabricated steel gratings, frames and rubbing strips shall be as detailed on the Drawings. Steel shall be to ASTM A 709, grade 36. Fabrication and galvanizing shall be carried out in accordance with Section 12 (Metal Works) of these Specifications.

Ductile iron gulley gratings and frames shall be as detailed on the Drawings and shall comply with the material and loading requirements of BS EN 124.

604.05 STEP IRONS

Step irons shall be galvanized cast iron in conformity with the Drawings and with BS EN 13101 provided that the weight of the step iron is not less than 1.5 kg.

604.06 STEEL LADDER

A. <u>General</u>

1. Fabricate steel ladders for the locations shown, with dimensions, spacing, details, and anchorages as indicated. Comply with requirements of BS 4211 and BS EN 14396. All components shall be hot dip galvanized to BS EN ISO 1461 with 610 grams of zinc per square meter to the dimensions and configurations shown on the Drawings. All components shall be fabricated prior to galvanising and no modifications to the components shall be allowed after galvanising unless with the prior written approval of the Engineer.

2. All materials, welding, galvanising etc., shall be carried out in accordance with Section 12 (Metal Works) of these Specifications. Provide safety cage as indicated on Drawings.

3. Space side rails [406mm (16 inches)] [457mm (18 inches)] apart, unless otherwise indicated.

4. Support each ladder [at top and bottom and not more than 1500mm (60 inches) o.c.] with welded or bolted brackets, made from same metal as ladder.

B. Side rails and Rungs

1. Side rails; continuous, [9.5-by-64mm (3/8-by-2-1/2-inch)] [12.7-by-64mm (1/2-by-2-1/2-inch)] steel flat bars, with eased edges.

2. Rungs; [19mm- (3/4-inch) diameter] [19mm- (3/4-inch) square] [25mm (1-inch) diameter] [25mm- (1-inch) square] steel bars.

3. Fit rungs in centre line of side rails; plug-weld and grind smooth on outer rail faces.

4. Provide nonslip surfaces on top of each rung by coating with abrasive material metallically bonded to rung by a proprietary process.

5. Galvanize ladders, including brackets and fasteners.

C. Ladder Safety Cages

1. Fabricate ladder safety cages to comply with BS 4211. Assemble by welding or with stainless-steel fasteners.

2. Provide primary hoops at tops and bottoms of cages and spaced not more than 20 feet (6m) o.c. Provide secondary intermediate hoops spaced not more than 48 inches (1200mm) o.c. between primary hoops.

3. Fasten assembled safety cage to ladder rails and adjacent construction by welding or with stainless-steel fasteners, unless otherwise indicated.

D. Steel Ladder Safety Cages

1. Primary Hoops: 6.4-by-100mm (1/4-by-4-inch) flat bar hoops.

2. Secondary Intermediate Hoops: 6.4-by-50mm (1/4-by-2-inch) flat bar hoops.

3. Vertical Bars: 4.8-by-38mm (3/16-by-1-1/2-inch) flat bars secured to each hoop.

4. Galvanize ladder cages, including fasteners.

604.07 SPECIALS

Cast iron specials shown on the Drawings but not specifically covered in BS EN 598, BS 4622 or BS EN 124 shall be to the approval of the Engineer, of reputable manufacture and made of material and of thicknesses such that the durability is equivalent to materials covered by those Specifications.

604.08 SAMPLES

The Contractor shall, before transporting any covers and frames, gratings and frames, step irons or ladders to the site, submit for approval of the Engineer two samples (Exept one sample for ladders) of each type to be used. All items used in the works shall conform to the approved samples.

The approved samples shall be retained by the Engineer until the completion of the Project.

No separate measurement or payment shall be made for the supply of samples.

604.09 PRISING AND LIFTING BARS

One prising and lifting bar of approved design or as shown on the Drawings shall be supplied by the Contractor with each hundred or part hundred ductile iron covers and frames.

605 - EARTHWORKS

605.01 GENERAL

This work shall comprise excavation, backfilling, compaction and removing unwanted excavated material for pipes in trench, drainage ditches, manholes, inlets, concrete trenches and headwalls and outlets for pipe drainage facilities. Work shall be carried out in accordance with Section 2 (Earthworks) of these Specifications and as specified herein.

Generally, excavation and backfilling shall be in accordance with Clauses 208.01 to 208.05 inclusive of Section 2 (Earthworks) of these Specifications, except that all installation of High Density Polyethylene Pipes shall be fully in accordance with the requirements of Clause 601.06 of these Specifications.

605.02 TEMPORARY WORKS

The Contractor shall make provision for all temporary work, scaffolding, staging, timbering, strutting, dewatering, cofferdams, bridgeways, and other works as may be necessary and required for the proper, safe and efficient performance and construction of the works to the satisfaction of the Engineer. The Contractor shall be responsible for any damage done to roads, mains, cables, including safety to persons and property, by the execution of the work.

The cost of furnishing, placing and removing the temporary works shall be included in the price bid for the work.

605.03 EXCAVATION IN TRENCH

Pipe trenches shall be excavated to the required depth and pipes shall be bedded in accordance with the details shown on the Drawings.

Foundation material supporting the pipe bedding shall be AASHTO M 145 Class A-1-a, A-1-b or A-2-4 compacted to 95% AASHTO T180 maximum density. If the natural material does not meet the classification requirements, it shall be sub-excavated to a depth of at least 200mm and replaced with material meeting the specified requirements. Any rock or hard material within 200mm of the bottom of the pipes shall be similarly sub-excavated and replaced with material meeting the specified requirements.

Where a pipe is to be installed partly in fill and partly in original ground or where a pipe is to be installed totally above original ground, the fill shall be constructed to a minimum height of 1000mm above the top of pipe level, or to the full embankment height whichever is lower, before the pipe is installed unless the Engineer agrees to the installation of the pipe prior to or during filling operations, in which case the Contractor shall provide, at his own cost, a 150mm concrete Class K 180 bed and surround to the pipe.

605.04 EXCAVATION FOR UNLINED DITCHES, LINED DITCHES, MANHOLES, KERB INLETS, DROP INLETS, CONCRETE TRENCH IN CARRIAGEWAY AND HEADWALLS AND OUTLETS FOR PIPE DRAINAGE FACILITIES

Lined and unlined ditches, manholes, kerb inlets, drop inlets, concrete trench in carriageway and headwalls and outlets for pipe drainage facilities shall be constructed to the details shown on the Drawings.

605.05 MACHINE EXCAVATION

Excavation by machine must not be executed deeper than 150mm above the bottom of the excavation unless otherwise approved by the Engineer.

The bottom of the excavation shall be carefully prepared in accordance with the Drawings.

605.06 MANUAL EXCAVATION

Manual excavation shall be used for final shaping and trimming of the trench invert in excavations.

Manual excavation must be used where existing services (cables, water, gas and oil mains, drainage pipes etc.) cross the excavation or in roads where traffic is likely to be unreasonably disturbed by the use of mechanical

plant. The Contractor will be held responsible for making good all damage caused by the use of mechanical plant.

605.07 OVER EXCAVATION

If due to negligence or error on the part of the Contractor any excavations are taken down to a level lower than is shown on the Drawings, the Contractor, at his own cost, shall fill in the void so formed to the proper level with approved material in layers not exceeding 150mm thick which shall be compacted in accordance with Clause 203.08 of Section 2 (Earthworks) of these Specifications where necessary by hand tamping, as directed by the Engineer. The finished trench invert shall be prepared accurately by means of hand tools. If the Engineer considers that concrete is necessary for this filling, then the Contractor shall provide and lay, at his own expense, Class K 180 concrete.

605.08 BRACING AND SHEETING OF EXCAVATION

Open cut excavations shall be braced and sheeted as may be necessary to protect persons, property, traffic or the work or to prevent settlement or collapse. The Contractor shall be responsible for any damage done to roads, mains, cables, pipes, drainage pipes, etc, by the excavation of the Works. When close sheeting is required, it shall be so driven as to prevent adjacent soil from entering the excavation either below or through such sheeting.

The Engineer reserves the right to order the sheeting to be driven to the full depth of the excavation or to such additional depths as may be required for the protection of the Works. Where the soil in the lower limits of excavation has the necessary stability, the Engineer, at his discretion, may permit the Contractor to stop the driving of sheeting at some designated elevation above the excavation bottom. Any such permission from the Engineer shall not relieve the Contractor of his responsibility under the Contract.

Where shown on the Drawings or directed by the Engineer, the Contractor shall leave the trench sheeting in place.

Excavation bracing must be removed when the backfilling has reached the respective levels of such bracing. If it is to be removed, sheeting must be removed after the backfilling has been completed or has been brought up to such an elevation as to permit its safe removal.

The cost of furnishing, placing, and removing sheeting and bracing shall be included in the price bid for the work.

605.09 STOCKPILING OF EXCAVATED MATERIAL

Excavated material shall be stockpiled in such a manner that it will not endanger the Works or any buildings, structures or property or obstruct the use of entrances, sidewalks, driveways, hydrants, manholes, and any other services or cause any obstruction to traffic. In particular the Contractor shall ensure that stockpiled excavated material does not obstruct pedestrian or driver visibility at road crossings, junctions etc.

Any damage resulting from Contractor’s failure to comply shall be rectified at the Contractor’s own expense, all as directed by the Engineer.

605.10 EXCAVATION OF UNSUITABLE MATERIAL

Unsuitable material will be defined and shall be disposed of as specified in Section 2 (Earthworks) of these Specifications.

The Contractor shall report in writing to the Engineer any unsuitable or weak ground material which may be found below the indicated excavation levels before executing any trimming of the excavation, pipe laying, concreting or other works.

Where the bottom of the excavation comprises unsuitable material including ashes, cinders, any type of refuse, vegetable or other organic material, or large pieces or fragments of inorganic material which in the judgement of the Engineer should be removed, the Contractor shall excavate and remove such unsuitable material to the width and depth ordered by the Engineer. The trench invert shall be made up by backfilling with approved material in layers not exceeding 150mm compacted thicknesses. The layers shall be compacted in accordance with Clause 203.08 of Section 2 (Earthworks) of these Specifications where necessary by hand tamping, as

directed by the Engineer so as to provide a uniform and continuous bearing and support for the pipe at every point between joint holes. The trench invert shall be finished by means of hand tools.

605.11 EXCAVATION IN ROCK

The definition of rock and method of its excavation shall be as specified in Section 2 (Earthworks) of these Specifications.

Any rock or hard material within 200 mm of the bottom of the pipes shall be sub-excavated and replaced with material meeting the specified requirements to make up the excavation to the required level under the pipe.

605.12 BLASTING

Blasting will be as defined in Section 2 (Earthworks) of these Specifications.

605.13 REMOVAL OF WATER FROM EXCAVATIONS

The Contractor shall at his own expense, provide, maintain and work such plant and equipment as is necessary to keep water at a level below the bottom of the permanent works for such periods as the Engineer may direct. The water shall at once be disposed off in a manner approved by the Engineer, which shall not cause any nuisance or injury. All sumps or wells which may be required for the purpose of keeping the Works dry shall be sunk clear of the Works and shall be filled in afterwards to the Engineer's satisfaction.

Where continuous pumping is necessary it shall not be stopped without permission from the Engineer. Pumping must be carried out in such a manner that fine-grained material is not washed out and carried away.

The water level will not be allowed to rise above newly cast concrete in conduits, manholes, joints, etc, for seven days or until, in the opinion of the Engineer, the concrete has acquired the necessary strength and water tightness**.**

605.14 BACKFILLING

All backfilling within the roadway limits shall be compacted to a minimum of 95% of AASHTO T 180 density. Backfilling outside the roadways limits shall be compacted to a minimum of 90% of AASHTO T 180 density. All compaction shall be done in layers not exceeding 150mm in thickness and fills shall be brought up simultaneously on all sides of the excavation.

Excavations shall be backfilled with suitable material without unnecessary delay, but not until pipes, manholes etc, and other construction details have been inspected and approved by the Engineer. Necessary precautions shall be taken during backfilling to ensure that pipes, manholes and other structures are not damaged. Any spaces left by the withdrawal of timbering and sheeting shall be properly filled immediately.

Backfilling, unless otherwise specified, shall be of the same material as was excavated provided that, in the opinion of the Engineer, it is suitable for backfilling. Under roadways, backfilling material must be the same as in the surrounding roads and in the same sequence of layers unless otherwise directed by the Engineer.

Trenches for non-plastic pipes shall be backfilled to a depth of 300mm above the top of the pipe by hand or by mechanical methods approved by the Engineer. The Contractor shall use special care in placing this portion of the backfill so as to avoid damaging or moving the pipe. The backfill material shall be placed in 150mm layers and compacted by tamping.

Backfill for HDPE or other plastic pipes shall be fully in accordance with the requirements of Clause 601 of these Specifications.

Where approved by the Engineer, surplus suitable and approved excavated material may be used for filling works within the project limits and in layers not exceeding 150mm and compacted as per Section 2 (Earthworks) of these Specifications.

605.15 MEASUREMENT AND PAYMENT

605.15.1 Basis of Measurement and Payment

A. Excavation In Trench

Measurement for pipe trenches shall be by the metre run for each pipe diameter and for each 1 metre depth stage. Measurement shall be for the length of trench only and shall exclude manholes, inlets etc.

Measurement for depth of each trench shall be the average of the depth at each end i.e manhole to manhole or inlet to inlet, and shall be calculated from the existing ground level or from the finished ground level or from the finished subgrade level, whichever is the lowest, to the trench invert level.

In the case where a pipe is (I) partly in fill and partly in original ground or (II) totally above original ground level and is enclosed in fill, the measurement for depth shall be the lesser of dimensions (i) and (ii) as calculated below.

Where trenches are to be excavated across existing roads or pavements which are to be re-opened to traffic on completion of the construction works specified herein, the depth of such trench excavation shall be calculated from the level of the top of the existing road or pavement to the trench invert level.

Dimension (i) - The depth between finished ground level or finished subgrade level, whichever is lower, and the underside of the pipe or pipe bedding (including concrete blinding) whichever is the lower.

Dimension (ii) - The outer diameter of the pipe plus 1000mm.

Payment for excavation in all types of soil including rock shall be at the rate in the Bills of Quantities, which rate shall include for all temporary works, dewatering, bracing, sheeting, testing, backfilling, compaction, and the use of approved surplus excavated material for filling (including compaction) in other areas of the site, for the disposal of surplus excavated material and/or unsuitable material as specified and for all other items necessary to complete the works.

In locations where a pavement is to be re-opened to traffic (either temporarily or permanently) on completion of the construction work specified herein, removal and reinstatement of existing pavement courses, precast concrete paving and street furniture shall be executed in accordance with Clause 1701 of Section 17 (Utilities Structures) of these Specifications.

Measurement and payment for such removal and reinstatement shall be in accordance with Clause 1701 of Section 17 (Utilities structures) of these Specifications and payment shall be made under Section 6 of the Bills of Quantities.

In locations where a pavement is not to be so re-opened to traffic (and for permanent removal of temporarily reinstated works) measurement for removal of existing pavement, precast concrete tiles/blocks and street furniture shall be according to Clause 207.08 of Section 2 (Earthworks) of these Specifications, and payment shall be made under Section 2 of the Bills of Quantities.

B. Excavation for Unlined and Lined Ditches

Measurement for unlined ditches, lined ditches, and other miscellaneous works shall be by the metre cube.

No measurement for ditch excavation shall be made for unlined ditches or lined ditches occurring within the limits of filling. The volumes of such ditches shall be excluded from the volume of filling calculated under Clause 205.01.5 of Section 2 (Earthworks) of these Specifications.

No separate measurement for ditch excavation shall be made for unlined ditches or lined ditches occurring within the limits of high level excavation. The volume of such ditches shall be included with the volume of high level excavation.

The volume of excavation measured shall be the product of the average net cross-sectional area of each excavation and its net length and shall be calculated from the existing ground level, finished ground level or finished subgrade level, which ever is the lowest to the excavation invert level.

Payment for excavation in all types of soil including rock shall be at the rate in the Bills of Quantities, which rate shall include for all temporary works, dewatering, bracing, sheeting, backfilling, compaction and the use of approved surplus excavated material for filling (including compaction) in other areas of the site, for the disposal of surplus excavated material and/or unsuitable material as specified and for all other items necessary to complete the works including grading and compacting bottom and slopes of ditches.

C. Excavation for Manholes, Kerb Inlets, Drop Inlets, Concrete Trench in Carriageway and Pipes Headwalls and Outlets

Measurement and payment for manholes, kerb inlets, drop inlets, concrete trenches in carriage way and pipes headwalls and outlets shall be covered by Clause 610 herein.

D. Unsuitable Material below Excavation Level

There will not be any separate measurement and payment for the removal and replacement of unsuitable material, the cost of which shall be included in the respective item.

605.15.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
605.1	Pipes Trench Excavation (diameter, depth stage)	m
605.2	Removal and Reinstatement of Existing Pavement Courses	sq.m
605.3	Removal and Reinstatement of Existing Precast Concrete Paving	sq.m
605.4	Removal and Reinstatement of Existing Street Furniture (Type)	nr
605.5	Excavation for Ditches and other Miscellaneous Works	cu.m

606 PIPE LAYING AND CONNECTIONS

606.01 SETTING OUT

Setting out shall be in accordance with Section 2 (Earthworks) of these Specifications. The Contractor shall clear from the route of each drainage pipe and the sites of all manholes, building connections and other appurtenances, all debris, vegetation and obstructions of whatsoever nature, as directed by the Engineer.

606.02 HANDLING OF PIPES

In distributing the material at the site of the works, each pipe shall be unloaded opposite or near the place where it is to be laid in the trench.

606.03 INSPECTION BEFORE INSTALLATION

All pipes shall be carefully inspected and examined for cracks, damage at joints and other defects immediately before installation in final position.

Pipes which do not conform with the Specification or which are found to be defective or damaged shall be rejected and removed from the work.

606.04 SIGHT RAILS

Sight-rails and properly established temporary bench marks shall be set in position alongside the work, using a surveyor's level. The practice of "transferring" levels by means of a straight edge and spirit level will not be permitted. The Contractor may use an alternative method for setting out if it is prior approved by the Engineer.

Where drainage pipes are to be constructed in trench, sight-rails shall be fixed across the trench at intervals of a maximum of 20m and at a height equal to the length of the boning rod to be used above the required invert level of the drainage pipe at the point where the sight-rail is fixed. There shall at no time be less than three sight-rails in position on each length of drainage pipe under construction at any one gradient.

606.05 LAYING

The pipes shall be laid and jointed immediately following excavation. The pipes shall be laid at the level and gradients as shown on the Drawings. The pipes shall be bedded as indicated on the Drawings. The pipes shall be aligned carefully both in line and level. Except where the pipe is to have a concrete bed or surround, supports shall not be placed under the pipe. Where necessary the bedding shall be scooped out at pipe joints to ensure the pipe rests only on the main barrel of the pipe and not on any widening at the joints. Joints shall be free from dirt and grease.

The Contractor is to exercise extreme care in making joints, including connections to manholes and gullies and other appurtenances to ensure that no leakage whatsoever occurs from the joints.

The Contractor shall ensure that all pipes and structures when laid or constructed are secured against floating, by backfilling or by some other approved means.

The Contractor must obtain the fullest possible information on the variations in water table and water courses that may affect the Works and shall carry out work having due regard to this information.

606.06 LEVEL TOLERANCES

Deviations from given levels may not be greater than ±20mm, and in the case of gradients flatter than 1 in 250, not greater than 1/20 of the given gradient.

606.07 UNSUITABLE CONDITIONS FOR LAYING PIPES

No pipe shall be laid when, in the opinion of the Engineer, conditions, are unsuitable.

606.08 GRANULAR BED AND SURROUND

Where specified on the Drawings, pipes shall be laid with granular bed and surround.

606.09 MEASUREMENT AND PAYMENT

606.09.1 Basis of Measurement and Payment

Measurement of the works incorporated under this Section shall be by metre run for each diameter and pipe material separately at any depth for the effective net length laid.

Payment shall be at the rate in the Bills of Quantities, which rate shall include for the supply of pipes and fittings, transporting, storing, cutting and waste, laying at any depth, jointing and making all connections to manholes, gullies, junctions and other appurtenances, testing and all things necessary to complete the works.

606.09.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
606.1	Pipes Supply and Installation (Diameter, Material)	m

607 JOINTS

607.01 GENERAL

For reinforced and unreinforced concrete pipes joints shall be sealed by elastomeric rings. Elastomeric rings must be maintained in placed in such a manner to ensure watertight joints during the specified tests, and the subsequent life of the installed pipes. The joint materials shall comply with application requirements of BS 7874 or other equal standard approved by the Engineer or shown on the Drawings.

HDPE pipes shall be jointed fully in accordance with Clause 601.05 of these Specifications.

607.02 RUBBER RING JOINTS

The instructions issued by the manufacturer of the jointing rings shall be followed carefully. When jointing pipes, a mark shall be made to check the position of the end of the barrel, unless it has a marking ring. In view of the flexibility of the joint, a gap 5 to 10mm wide shall be left between the ends of the pipes. In the case of flexible spigot and socket joints, the joint shall be made in accordance with the manufacturer's recommendations to ensure full flexibility. When the connection is complete, the ends of the pipes shall be checked by means of the mark. When pipes are to be laid in curves, the pipe shall not be bent sideways until the connection has been made. Elastomeric rings shall be stored in a cool dark place. The use of lubricants for roll-on gaskets shall not be permitted.

607.03 MEASUREMENT AND PAYMENT

Joints shall not be measured or paid for separately. All labour, materials, equipment and associated work shall be considered as incidental to and included in the rates for pipe-laying.

608 - TESTING INSTALLED PIPELINES

608.01 GENERAL

The Contractor shall test all drainage pipelines, joints, fittings; gulley runs etc., before carrying out haunching or encasement of pipes or backfilling of trenches. The tests shall be carried out between manholes or a lesser distance, to the satisfaction of the Engineer. Prior to testing, final cleaning of every pipeline, manhole shall be carried out by the Contractor and approved by the Engineer.

All pipelines and concrete works shall be clean and dry and the joints shall not be covered with earth prior to testing.

For each pipeline 300mm or less in internal diameter a mandrel test shall be performed. All pipelines 600mm or less in diameter shall be tested by an air test. Should any pipe fail the air test, the Engineer may order a water test to be carried out. Acceptance of the pipeline will then be based on the results of the water test.

All pipelines 800mm or greater in diameter shall be inspected internally to the satisfaction of the Engineer.

The Engineer may, in addition to the internal inspection, order a smoke test to be carried out on any pipeline and in such cases acceptance of the line will be based on the results of the smoke test and of the internal inspection.

The result of all the tests shall be recorded on special forms and submitted to the Engineer for approval.

Any pipelines not passing any of the tests shall have the defects made good and shall be retested using the appropriate test designated above.

Should any pipe show cracks, holes or any other defect the Engineer shall have the right to reject and instruct the Contractor to remove and replace the pipe in a satisfactory manner. Should any leakage from any joint occur the Contractor shall remove and refit the pipes to the satisfaction of the Engineer. The cost of all tests, replacement and/or repair work etc. shall be borne by the Contractor.

608.02 THE MANDREL TEST

A wooden mandrel measuring 300mm long and 10mm less in diameter than the nominal diameter of the pipe shall be pulled through each pipe length in both directions to ensure that there are no obstructions in the pipes. Should any obstruction be met the Contractor shall submit his proposals for removing the obstruction. These proposals must be approved by the Engineer before any corrective measures are taken by the Contractor. Should the Engineer not approve the Contractor's proposals or should it prove impossible to remove the obstruction the Engineer may instruct that the pipe length be replaced at the Contractor's expense.

608.03 THE AIR TEST

608.03.1 HDPE Pipes

Completed HDPE pipe run shall be air pressure tested in accordance with ASTM F1417.

608.03.2 All Other Pipes

All other pipes shall be air tested as follows:

Air shall be pumped in by suitable means until a pressure of 100mm head of water is indicated in a U-tube connected to the system. A 5 minute period shall be allowed for stabilisation during which time the air pressure shall be kept topped up to maintain the 100mm head of water. Following the stabilization period, the air pressure shall not fall to less than 75mm head of water during the test period of 5 minutes.

608.04 THE SMOKE TEST

608.04.1 HDPE Pipes

HDPE pipes shall not be smoke tested.

608.04.2 All Other Pipes

All other pipes shall be smoke tested as follows:

Smoke shall be pumped in by suitable means and a pressure of 100mm head of water maintained for a minimum of 5 minutes. Any leakages from the pipeline or joints shall be marked and on completion of the test all defects shall be repaired by the Contractor at his own expense. The test shall then be repeated until satisfactory results are obtained. The Engineer shall have the authority to reject any pipes or joints which in his opinion are unsuitable for repair and the Contractor shall replace the same at his own expense.

608.05 THE WATER TEST

608.05.1 HDPE Pipes

HDPE pipes shall not be water tested.

608.05.2 All Other Pipes

Other pipes shall be water tested as follows:

The pipes shall be completely filled with water under a head of not less than 1500mm above the crown of the pipe at the high end and not more than 6m above the crown of the pipe at the low end. Steeply graded pipe lines shall be tested in sections so that the above maximum shall not be exceeded. Unless otherwise agreed by the Engineer the test shall commence one hour after filling the test section at which time the level of the water at the vertical feed pipe shall be made up to produce the required 1500mm minimum test head.

The loss of water over a 30 minute period shall be measured by adding water at regular 10 minute intervals to maintain the original water level and recording the amounts so added. The pipeline will have passed the test if the volume of water added does not exceed 0.12 litres per hour per 100 metres of drain length, per mm of nominal internal diameter.

If, in the opinion of the Engineer, pipes show signs of leakage during or after the test then the Engineer shall reject such pipes or instruct any measures he deems necessary to rectify such defects to be undertaken by the Contractor at the Contractor's expense. The Contractor shall not be allowed to use brackish or sea water for the

purpose of tests. The Contractor shall bear all the costs regarding supply, flushing and satisfactory disposal of water for use in the tests.

608.06 FURTHER TESTING FOR HDPE PIPES

a. HDPE Pipe shall be tested for 'Resistance to Internal Puncture' in accordance with WIS 4-35-01.

   1. The point of impact shall be adjusted such that it is in the thinnest section, typically in the middle of the hollow corrugation.

b. HDPE Pipe shall be tested for 'Resistance to Water Jetting' in accordance with WIS 4-35-01.

   1. The test shall be modified such that the minimum test pressure shall be 100 Bar.

c. HDPE Pipe shall be tested for 'Resistance to Longitudinal Bending' in accordance with WIS 4-35-01.

608.07 PIPE DEFLECTION FOR HDPE PIPES

Installed HDPE pipes larger than 100mm diameters shall be measured for deflection. The initial Bedding Acceptance test shall be conducted by a deflectometer for pipes sizes DN 600mm and below and by manual measurement or deflectometer for pipelines of DN greater than 600mm.

% Deflection Limits for HDPE Pipe

Maximum Limits

Diameter	**Pipe Acceptance (Notes A & B)**	**Bedding Acceptance (Note C)**	**Installationa Acceptance (Note D)**
DN 600mm and smaller	5.0	2.5	3.0
DN over 600mm	1.25*	0.625*	0.750*

* Numbers shown are the average of the vertical and horizontal deflections individual measurements of either the vertical or horizontal diameter may show deflections, by comparison to the reference diameter, of four times the value listed above.

The mandrel shall have a cylindrical cross section, with a diameter not smaller than 10mm less than the minimum acceptable pipe diameter, given in the table.

Notes:

a. Pipes whose deflection at any time has exceeded this value will not be accepted for incorporation into the work. This test may utilise a mandrel and shall be carried out not less than 1 year after completion of backfilling, but prior to expiry of guarantee period.

b. The Contractor should note that 10 percent of the total installed cost (pipe, bedding, backfill and testing) shall be withheld until completion of testing and approval of flexible pipe. The costs withheld would be released to the Contractor subject to a submittal of unconditional Bank Guarantee. The above withholdal is in addition to that held from the Contractor in Interim Payments made to him.

c. To be measured after placing of the surround material, and after withdrawal of trench sheeting to above the crown of the pipe, but before backfilling. For non-pressure pipes, the permissible percentage deflection will be accepted only as an elongation of the vertical diameter, and no reduction will be acceptable at this stage.

d. To be measured not less than four weeks after completion of backfilling.

608.08 CCTV INSPECTION

CCTV Inspection shall be conducted on all completed pipe lines to the approval of the Engineer.

608.09 DAMAGE CAUSED BY BACKFILLING AND CONCRETE HAUNCH OR ENCASEMENT

If in the opinion of the Engineer any damage occurs to the pipelines through the process of placing a concrete haunch or encasement, or backfilling the pipeline, the Engineer shall order retesting of the doubtful part by the appropriate test method. If such testing proves that the pipeline is not serviceable, then the Contractor shall locate the damage, make it good and carry out retesting until he secures satisfactory results to the approval of the Engineer. The cost of all such works shall be borne by the Contractor.

608.10 MEASUREMENT AND PAYMENT FOR TESTING

Testing shall not be measured or paid separately. All labour, materials, equipment and associated work shall be considered as incidental to and included in the rates for pipe laying.

609 - CONCRETE WORKS FOR PIPE-LAYING AND DITCHES

609.01 GENERAL

All concrete works shall be in accordance with Section 5 (Concrete Works) of these Specifications. Type V cements shall be used in all cases.

609.02 CONCRETE HAUNCHING AND ENCASEMENT

Where specified on the Drawings or as directed by the Engineer, concrete haunching or encasement of pipes shall be provided. No backfilling of the trench shall be commenced until the concrete has hardened to the approval of the Engineer.

609.03 PLAIN CONCRETE

The following classes of sulphate resisting concrete shall be used:

a. Class K180 for haunch or encasement to pipes.

b. Class K250 for benching including 20mm thickness of smooth hard surface finish.

c. Class K 180 for blinding.

609.04 REINFORCED CONCRETE

All reinforced concrete works, whether precast or in-situ, shall be of the Class shown on the Drawings, using Sulphate resisting cement unless otherwise specified.

609.05 SAND ASPHALT DITCH LINING

Where shown on the Drawings, drainage ditches shall be lined with Sand Asphalt.

Materials, equipment and workmanship for sand asphalt ditch lining shall comply with Clause 304 of Section 3 (Sub-base and Base Courses) of these Specifications and the relevant portions of Clause 411of Section 4 (Asphalt Works) of these Specifications.

609.06 JOINING PIPES AT EXISTING BOX DRAINS OR EXISTING MAIN DRAINS

Where new concrete pipes join an existing box drain or existing main drain, the concrete of the existing box drain or main drain at the point of joining shall be removed as required to expose the reinforcing steel and allow a minimum lapping of 400mm of the existing and new reinforcing steel.

Removal of the existing concrete shall be done in such a manner as to avoid causing cracks or damage to the existing concrete where it is to remain. All cracked or damaged concrete caused by this operation shall be cut back and replaced at the Contractor’s expense and to the satisfaction of the Engineer.

The concrete surfaces to be joined shall be vertical along a plane normal to the longitudinal axis of the existing drains.

The construction joint between the existing and new concrete shall be an epoxy resin joint as specified in Section 5 (Concrete Works) of these Specifications.

The joint shall be encased in a minimum 150mm of K250 concrete unless otherwise shown on the Drawings.

609.07 MEASUREMENT AND PAYMENT

609.07.1 Basis of Measurement and Payment

A. Plain Concrete

Plain concrete work shall be measured by the metre cube in accordance with Clause 504.08 of Section 5 (Concrete Works) of these Specifications.

Payment shall be at the rate in the Bills of Quantities, which rate shall include temporary works, formwork, joints, curing, testing etc, and all things necessary to complete the works.

B. Reinforced Concrete

Reinforced concrete work shall be measured by the metre cube. Payment shall be at the rate in the Bills of Quantities, which rate shall include temporary work, formwork, moulds, reinforcement, concrete, curing, testing, joints and all things necessary to complete the works.

C. Sand Asphalt Ditch Lining

Measurement and payment for sand asphalt ditch lining shall be as Clause 304.04 of section 3 (Sub-base and Base Courses) of these Specifications. In addition to the requirements of Clause 304.04 rates shall also include for prime coat, laying and compacting to the various ditch profiles and for working around drainage outlets, obstructions, etc.

D. Joining Pipes at Existing Box Drains or Existing Main Drains

1. The work shall be numerated stating the type of connection. Payment shall be at the rate in the Bills of Quantities which rate shall include all labour, materials, equipment, forming openings, jointiong, making good and all associated work necessary to complete the works.

2. The Box-out opening in Manhole / Gully wall for concrete pipe connection shall be in rich cement mortar (1:3) including back plaster collar of minimum (25mm) cement mortar (1:3) to the satisfaction of the Engineer and as shown in the Drawing.

609.07.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
609.1	Plain Concrete (class, location)	cu.m
609.2	Reinforced Concrete (class, location)	cu.m
609.3	Sand Asphalt Ditch Lining (Type, Thickness)	sq.m
609.4	Pipe Connection to Existing Drain (Type)	nr

610 - CONCRETE WORK FOR MANHOLES, INLETS, CONCRETE TRENCH IN CARRIAGEWAY, AND PIPE HEADWALLS AND OUTLETS

610.01 CONSTRUCTION

a. Manholes, kerb inlets, drop inlets, concrete trenches in carriageway and headwalls and outlets for pipe drainage facilities shall be constructed to the details shown on the Drawings. Concrete works shall be in accordance with Section 5 (Concrete Works) of these Specifications and Sulphate resisting cement shall be used in all cases.

b. Step irons shall be staggered at 300mm centres vertically and horizontally, and shall either be set in place or grouted in using epoxy grout.

c. Ladders shall be provided where the height from the benching to the cover is greater than 3metres.

610.02 TOLERANCES

In paved areas (roads, bus bays, parking areas, sidewalks etc,) covers, gratings and frames shall be set to follow finished levels with a tolerance of ±3mm.

In non-paved areas covers and frames shall be set to a tolerance of ±10mm.

610.03 MEASUREMENT AND PAYMENT

610.03.1 Basis of Measurement and Payment

Manholes, kerb inlets, drop inlets, headwalls and outlets shall be measured by number of each type. The rate shall include for everything necessary to complete the work including earth work, plain and reinforced concrete work, benching, reinforcing steel, protective membrane, painting, water stops, step irons, ladders, gratings and frames, rubbing strips, manhole access covers and frames etc.

Concrete trenches in pavements shall be measured by metre length for each trench size presented as width (m) x average depth (m). The rate shall include for everything necessary to complete the work including earth work, plain and reinforced concrete work, reinforcing steel, protective membrane, painting, water stops, gratings, etc.

Payment shall be at the rates in the Bills of Quantities which rates shall include for all labour, plant and materials and everything necessary for the proper execution of the work including all necessary temporary works, testing and all other items and work in connection with the construction of the work, unless it is specificed and measured separately.

610.03.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
610.1	Manhole (Type)	nr
610.2	Inlet (Type)	nr
610.3	Outlet Structure for Drainage Pipe (Type)	nr
610.4	Concrete Trenches in Pavements (Size)	m

611 - MODIFICATION OF EXISTING MANHOLES

611.01 CONSTRUCTION

Where the cover level of the manhole is to be raised or lowered, the Contractor shall remove the cover, cover slab, if present, and top portion of the existing manhole as indicated on the Drawings and as specified herein. The Contractor shall excavate and remove the existing construction or raise the manhole walls in concrete as required, and provide a new concrete cover with reinforcing steel as indicated on the Drawings. Concrete grades/classes shall be as shown on the Drawings. The excavation shall be backfilled with pervious backfill as specified in Section 2 (Earthworks) of these Specifications.

Where the arrangement of pipe entries and exits in the manhole is to be modified the Contractor shall excavate externally and break through the manhole wall for provision of the new drainage pipe. Drainage pipes to be abandoned shall be plugged with K180 concrete. Where the invert of the manhole is to be raised the base of the manhole shall be thoroughly cleaned and scabbled and benching formed in concrete of the grade/class shown on the Drawings, to the required levels.

611.02 TOLERANCES

The tolerances stated under Clause 610.02 of these Specifications shall apply to this work.

611.03 MEASUREMENT AND PAYMENT

611.03.1 Basis of Measurement and Payment

Measurement for raising manholes or the like shall be enumerated for each type separately, stating the height raised in stages of 0.50 metres.

Measurement for lowering manholes or the like shall be enumerated for each type separately, regardless of the depth lowered.

Measurement for re-arrangement of pipe entries and/or exits to manholes, inlets or the like shall not be measured or paid separately. All labour, materials, equipment and associated work shall be considered as incidental to and included in the rates for pipe laying

Abandonment of drainage pipes and/or drains shall be measured as specified in Clause 207.08 of Section 2 (Earthworks) of these Specifications.

Raising inverts of manholes, inlets or the like shall not be measured or paid separately. All labour, materials, equipment and associated work shall be considered as incidental and included in the rates of Section 6 of Bills of Quantities.

Payment shall be under Section 6 of the Bills of Quantities and shall include for all labour, plant and materials and everything necessary for the proper execution of the work, including all necessary temporary works, testing and other items and work in connection with the construction, including connecting of existing pipes to the modified construction and taking necessary measures to maintain flow.

611.03.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
611.1	Raising Manholes or the Like (Type and Height Raised)	nr
611.2	Lowering Manholes or the Like (Type)	nr
611.3	Grouting of Abandoned Drainage Pipes (Diameter)	m

612 - BOX CULVERTS AND CONDUITS

612.01 GENERAL

Box culverts and conduits are to be constructed to the details shown on the Drawings and as instructed by the Engineer.

Excavation and backfilling shall be carried out in accordance with Clauses 208.01 to 208.05 inclusive of Section 2 (Earthworks) of these Specifications. Concrete works shall be carried out in accordance with Section 5 (Concrete Works) of these Specifications and as specified herein.

The work shall consist of providing plain and reinforced concrete mixes of different classes in accordance with the Drawings and Specification, transportation and placing of concrete, supply and installation of framework and temporary works, supply, cutting, bending and placing of reinforcing steel, vibrating, tamping, curing, removal and disposal of formwork and temporary works when no longer required. All structural concrete shall be K-350 for main culvert, manhole necks, access openings, transitional structures etc. Including all expansion and construction joints except in situation where the culvert is exposed to aggressive ground water condition or marine environment (tides, waves etc) and the concrete shall be of K415 for durability reasons. Concrete for outfall structures also shall be of K415. Blinding and encasement concrete shall be K-180.

Where sections of new culvert are to be joined to existing culvert, the area around the joint shall be thoroughly cleaned beforehand of any material adhering to it. The existing concrete shall be cut back sufficiently to expose the reinforcement steel to provide a lap length as shown on the Drawings. The cut shall be finished to a straight

line with the joint perpendicular to the concrete face. The surface of the joint shall be treated as a plain bonded construction joint as described in the Specifications.

612.01.1 Cement and Cementitious Material

All reinforced concrete used in the stormwater box culvert works including shafts shall be formed from (OPC) Type I blended with either Ground Granulated Blast Furnace Slag (GGBFS) or Pulverised Fuel Ash (PFA) in accordance with the combination detailed below.

All non-reinforced concrete used in the stormwater box culvert works shall be formed from Sulphate Resisting Portland cement Type V.

Subject to the approval of the Engineer, cementitious materials in the stormwater box culvert works shall be used in one of the following combinations with each component complying with the relevant standard:

a. Portland cement Type I to ASTM C150 and Ground Granulated Blast Furnace Slag (GGBFS) to ASTM C989 with proportion of GGBFS by weight not exceeding 75% ± 3%. The cement and the GGBFS shall be added separately at the batching plant. The maximum alumina (AL_2O_3) content of the GGBFS shall not exceed 14%.

b. Portland cement Type I to ASTM C150 and Pulverised Fuel Ash (PFA) to ASTM C618 with the proportion of PFA by weight of 35% ± 3%. The cement and the PFA shall be added separately at the batching plant.

The acid – soluble alkali content of the components of the cementitious materials, expresses as equivalent sodium oxide and calculated as $Na_2O + 0.658K_2O$, shall be less than 0.6% by weight, i.e. maximum 0.6% (ASTM C150).

Each type of cement or component of a cementitious mixture for incorporation in the stormwater box culvert works shall be obtained from a single source approved by the Engineer. Before any type of cementitious material is delivered to the Site the Contractor shall submit, for the Engineer's approval, full details of tests and analysis and certificates showing that the cementitious materials comply with the Specification and relevant Standards.

In addition each consignment of cementitious material shall be accompanied by a certificate in English from the manufacturer showing that the material offered has been tested and analysed, the date of such tests and analysis and that such tests and analysis comply in all respects with this Specifications.

In addition to the information required by ASTM C150, ASTM C989 and ASTM C618 certificates of consignment of cementitious materials shall also state:

1. The percentage of total alkalis present in the cementitious material.

2. The tricalcium silicate (C_3S_2) content.

3. The tricalcium aluminate (C_3A) content and.

4. The chloride content.

Cementitious materials which have been manufactured more than 6 months prior to the poposed date of delivery to the Site shall, in addition, be inspected, sampled and tested for compliance as directed by the Engineer in an independent laboratory before the Engineer shall consent to its delivery to the Site. No cementitious material shall contain lumps.

612.01.2 Classes of Concrete

Refer to Section 5 "Concrete Works".

612.01.3 Reinforcing Steel

Refer to Section 5 "Concrete Works".

612.01.4 Ready-Mixed Concrete

Refer to Section 5 “Concrete Works”.

612.02 TEMPORARY WORKS

The Contractor shall make provision for all temporary work, scaffolding, staging, timbering, strutting, dewatering, cofferdams, bridge ways, and other works as may be necessary and required for the proper, safe and efficient performance and construction of the works to the satisfaction of the Engineer. The Contractor shall be responsible for any damage done to roads, mains, cables, etc., including safety to persons and property, by the execution of the works.

The cost of furnishing, placing and removing the temporary works shall be included in the price bid for the work.

612.03 SEA OUTFALL STRUCTURE

612.03.1 General

Sea Outfall structure are to be constructed to the details shown on the Drawings and as instructed by the Engineer. The work shall consist of providing plain and reinforced concrete mixes of different classes in accordance with the Drawings and Specifications, transportation and placing of concrete, supply and installation of formwork and temporary works, supply, cutting, bending and placing of reinforcing steel, vibrating, tamping, curing, removal and disposal of formwork and temporary works when no longer required.

The work shall also consist of providing all necessary slope and erosion protection measures to the area downstream of the outfall such as armour layer of quarried rock placed on the top or outer layer(s) of structure and/or slope exposed to sea conditions to provide protection against erosion and wave action, an underlayer quarried stone placed under the armour rock layer and governed by filter rules to prevent migration of underlayer material through the armour layer, and a filter fabric (geotextile) membrane placed between the underlayer and the seabed soil or the core material to allow passage of water while retaining of seabed soil and core materials in place without clogging. Geotextile shall be specified with sufficient puncture resistance to prevent damage. The slope protection shall also include toe protection against scouring and undermining of structure and support against sliding to the structure armour/face. the work shall consist of providing rocks of different classes and gradation in accordance with Drawings and Specifications, transportation, storage and placing of armour, underlayer, core material (if necessary) and filter fabric, dredging in case of embedded toe, construction of containment bunds if necessary, seabed clearance and removal of unsuitable material before the commencement of works.

612.03.2 Definitions

a. *Quarried stone* consists of natural rock imported to site from approved quarry sites complying with the requirements of this Section.

b. *Quarry run* consists of natural rock fragments and complying with the requirements of this Section.

c. *Armour rock* is the quarried stone placed in the top or outer layer(s) of the structure exposed to sea conditions.

d. *Underlayer* is the quarried stone placed under the armour rock layer(s).

e. *Core* means the quarry run material forming the bulk portion of the slope and erosion protection fill sections protected by underlayers and/or armour rock.

f. *Filter fabric (geotextile)* is a membrane placed between the underlayer and the seabed soil or the core stone to allow passage of water while retaining of seabed soil or core stone in place without clogging.

612.03.3 Submittals

a. Submit to the Engineer for his approval a Quality Control Manual for the proposed slope and erosion protection construction.

b. Method statements: submit the following method statements to the Engineer for his approval at least 45 days prior to the commencement of work on site:

1. Method for preparation of seabed as the base.
2. Method for placement of core material, underlayer and rock armour protection.
3. Method for surveying procedures to establish lines and levels of the various slope and erosion protection components.
4. Method of quarry selection and armour stone production.

c. Test reports: The following reports are to be submitted directly to the Engineer from approved testing services, with a copy to the Contractor:

1. Grading size of material
2. Aspect ratio of material
3. Apparent oven dry density of quarried stone
4. Los Angeles abrasion
5. Water absorption
6. Sodium sulphate soundness
7. Unconfined compressive strength
8. Methylene blue absorption

d. Shop drawings: submit detailed design drawings, plans, longitudinal profiles and cross-sections across the slope and erosion protection at 50m intervals and at transition zones between the different design sections. The drawings shall be based on the up-dated survey carried out at the slope and erosion protection area.

e. Submit bathymetric charts for the slope and erosion protection area below water line, as applicable, at suitable scales including ACAD computer file diskettes in the form of point No., x, y, z if requested by the Engineer on site.

612.03.4 Quality Assurance

a. Codes and Standards: perform work in accordance with:

1. The requirements of the Authorities.
2. BS 6349, BS 812 and ASTM D 1557, ASTM C 131, ASTM D 4354, ASTM D 4873.
3. Recommendations of Construction Industry Research and Information Association (CIRIA) Special Publication No.83 (SP 83).
4. ISRM -1986.

b. Testing and inspection services: Employ and pay for a competent independent geotechnical testing laboratory with proven track records to perform testing on rock material to be placed in the core, underlayers and armour layers of the structure.

612.03.5 Products

612.03.5.1 Quarried stone for armour layers and underlayers

a. Stones: Use armour and underlayer stones consisting of quarried rock, dense, sound, fresh, strong, free from weathering, mechanical weaknesses or chemical decomposition. The stones shall not be liable to decomposition under the action of sea water. They shall also be free from any visible defects such as joints, discontinuities, fractures, clay seams or bands and water soluble material.

b. Grading: Use rock materials in armour layers and underlayers conforming to the classes defined by the Engineer.

c. Shape: Use quarry stone containing no more than 5% of stones with a length to thickness (l/d) ratio greater than 3, where the length (1), is defined as the greatest distance between two points on the stone and the thickness,(d), as the minimum distance between two parallel straight lines through which the stone can just pass. Carry out the test in accordance with CIRIA SP.83, Appendix 2.

d. Apparent oven dry density: Use quarry stone for armour and underlayers for testing having a minimum apparent oven dry density of 2560 kg/m3 with 90% of the stones having a density of at least 2600 kg/m3 in accordance with CIRIA SP 83.

e. Abrasion: The loss of material using the Los Angeles Abrasion test in accordance with ASTM C-131 shall not exceed 35%.

f. Water absorption: The water absorption of quarry stone, carried out in accordance with BS 812: Part 2 shall be less than 3%.

g. Soundness: Sodium sulphate soundness carried out in accordance with BS 812: Part 121 using the 63-125mm crushed rock and a 50mm sieve to determine losses shall be less than 12%.

h. Strength: The average point load index Is (50) in the planar direction of the most pronounced layering, should any visible anisotropy exist, and for sampling testing and reporting in accordance with ISRM 1986 recommended method, shall be not less than 4.0 MPa with the average minus the standard deviation of the point load index at least 3.0 MPa; where at least ten valid test results obtained from pieces originating from ten randomly selected stones have been used to calculate the average and standard deviation.

i. Methylene blue absorption: Methylene blue absorption tests shall be carried out in accordance with CIRIA SP 83, Appendix 2, in order to indicate the presence of deleterious clay minerals, the results of this test shall not exceed 1.0g/100g.

j. Testing: Carry out for each quarry the three sets of tests as listed in Clauses 612.03.5.1(A) to 612.03.5.1(I). Submit the results for the Engineer's approval of the source of quarried stone for underlayers and armour layers.

k. Testing: Carry out at least three sets of the tests listed in Clauses 612.03.5.1(A) to 612.03.5.1(I) on each consignment of quarried stone for under-layers and armour layers imported to site. A higher frequency of testing may be required as instructed by the Engineer, if this, in the opinion of the Engineer, is deemed necessary.

l. Rejections: Materials failing to comply with any of the requirements in Clauses 612.03.5.1 (A to I) shall not be used in the Works and shall be considered not in compliance with these Specifications.

612.03.5.2 Core material

a. Use core material consisting of well graded quarry run complying with the gradation defined by the Engineer.

b. Fill material shall be quarry run material with percentage of fines (passing sieve 0.075mm) shall not be more than 20%.

c. Use selected quarry run with material percentage lighter than 1.0 kg (80mm of equivalent diameter) not exceeding 10% and complying with the size gradation defined by the Engineer.

d. Use quarry run material complying with the following requirements:

1.	Apparent oven dry density	> 2.3 t/m^3
2.	Water Absorption	< 3.0 %
3.	Sodium Sulphate Soundness	< 12.0 %
4.	Los Angeles Abrasion	< 35.0 %
5.	Methylene blue absorption	< 1.0g/100g

e. Testing: Carry out for each quarry three sets of the tests as listed in Clauses 612.03.5.2 (A-D). The selection of the quarry source will be based on the results submitted and subject to Engineer's approval.

f. Testing during execution: During construction take sufficient sample for every 5000 tonne of material produced or production for a working day whichever is greater. Three sets of the tests as listed in Clauses 612.03.5.2 (A-D) shall be carried out and submitted to the Engineer. A higher frequency of testing may be required as instructed by the Engineer, if this, in the opinion of the Engineer, is deemed necessary.

g. Rejections: Materials failing to comply with any of the requirements in Clauses 612.03.5.2 (A to D) shall not be used in the Works and shall be considered not in compliance with these Specifications.

612.03.5.3 Filter fabric - geotextiles

a. Function: The work shall consist of furnishing and placing a geotextile. The geotextile is designed to allow passage of water while retaining seabed soil without clogging. The suitability of used geotextile should be checked against these functional requirements before laying taking into consideration the seabed soil conditions.

b. Material: Non-woven TERRAM 4000 or equivalent material can be used with the following properties:

   1. Weight : 350 g/m^2

   2. Tensile strength : 23 kN/ m^2

   3. O_{85} (diameter of holes in a fabric) : a suitable hole diameter to prevent the wash out of seabed and core material and to retain them in place without clogging.

c. Geotextile deterioration: provide evidence of the resistance to deterioration of the geotextiles from exposure to ultraviolet light and seawater.

d. Carry out sampling of geotextiles for testing in accordance with sampling procedures indicated in ASTM - D4354-99.

e. Testing: Carry out for geotextiles three sets of tests to certify the required properties listed in Clause 612.03.5.3 (B) submit the results for the approval of the Engineer.

f. Testing: Carry out at least three sets of tests to verify the required properties listed in Clause 612.03.5.3 (B) on each consignment of geotextile imported in the Site. A higher frequency of testing may be required as instructed by the Engineer, if this, in the opinion of the Engineer is deemed necessary.

g. Rejections: Materials failing to comply with any of the requirements in Clause 612.03.5.3 (B) shall not be used in the Works and shall be considered not in compliance with these Specifications.

612.03.6 Execution

612.03.6.1 General

a. Seabed sounding and sampling: Carry out sounding of the seabed at the slope and erosion protection site in order to produce a detailed seabed profile using echo sounder or side-scan sonar together with a surface-towed sub-bottom or similar seismic profiler and a tide gauge and collecting seabed samples. Obtain approval of the Engineer on the results of soundings and bathymetry as well as seabed samples before the works commence, and finally incorporate the same in the shop drawings.

b. Seabed clearances: Remove prior to commencing filling works, all unsuitable material, wrecks, floating debris, silt, clay, loose sand and loose material over the whole area of the slope and erosion protection. Dispose of unsuitable material as directed by the Engineer.

c. Removal of unsuitable material: Remove, in accordance with the instructions of the Engineer any silt, loose sand or clay that exists in the top layers of the seabed. Remove any silt, loose sand and clay layers to the levels and areas as instructed by Engineer.

d. Underwater services: Relocate or redirect, at Contractor’s expense, all underwater services, installations etc. that may lie in the area to receive rockfilling. Carry out all such redirection or relocation in accordance with requirements of the relevant local authorities.

e. Founding bed: Ensure that the founding bed for slope and erosion protection is natural seabed material when working in the sea, consisting of sand, a mixture of sand and gravel or rock. No filling on silt, loose sand or clay layers shall be allowed.

f. Make arrangements for the supply and transport of slope and erosion protection material either by land or sea or both and use appropriate marine and/or land operated plants for filling.

g. Damage due to sea conditions: Protect all placed material from erosion by the action of sea during construction. The Contractor shall be held responsible for all loss of material and displacements that may arise, and shall make good such losses and displacements at his own expense. Furthermore, the Contractor

shall be responsible for any obstruction that may be caused by the deposition of any material washed out from the filling and remove the same in accordance to the instructions of the Engineer.

h. Take all the necessary precautions to protect the environment and any damage to the environment arise from the Works shall be the Contractor's responsibility.

612.03.6.2 Placement of core material

a. Place materials used to form the core to the profiles and levels shown on the Drawings with a tolerance of zero above the theoretical level.

b. Take measurement of each material profile as placed before any subsequent layer of material is placed to ensure compliance with the specified tolerances.

c. Carry out placement of core material underwater in such a manner to minimize segregation of material and to ensure its proper mixing. The placement methods are subject to Engineer's approval.

d. Place core material 0.75m above mean sea level and higher in layers not more than 1.0m in loose depth and compact as specified.

e. Before compaction, moisten each layer as necessary. Compact each layer with the minimum number of roller passes as agreed with the Engineer.

f. Carry out compaction by heavy vibratory compactor not less than 12 tonne capacity..

612.03.6.3 Placement of armour and underlayer stones

a. Bulk-placed stones: For placing above high low water level, place the stone to grade and in such a manner to ensure that the larger rock fragments are uniformly distributed and the smaller rock fragments fill the spaces between the larger fragments to achieve a well keyed, densely packed structure of the specified dimensions. Hand placing or barring will be required only to the extent necessary to secure the results specified.

b. Individual stones: Do not drop or tip into position quarried stone, but place them individually into the structure in order to achieve an adequate stability and deformation to maintain lines and levels shown on Drawings. Tightly pack the stones together so as to achieve as near as possible a target unit weight of stone placed of 1.6 t/m3 and do not place them so that they can rock or obtain their stability on a plane by frictional resistance alone prior to placing further stones.

c. Voids: Fill any void below finished profile level in excess of mean rock size with an appropriate stone or stones.

d. Tolerances:

1. Vertical tolerances: Place rock materials to the levels, dimensions and slopes shown on Drawings, and the surface profile measured in accordance with the surveying procedure outlined in Clause 612.03.6.4 of these Specifications, to be within the vertical placing tolerances given in the Table below.

2. Thickness tolerances: The tolerance on two consecutive mean actual profiles shall not be negative. Notwithstanding any accumulation of positive tolerances on underlying layers, the thickness of the layer shall not be less than 80% of the nominal thickness when calculated using mean actual profiles.

Depth of Placing Below Low Water Level	All Armour Layers and Individual Measurements (m)	Design Profile to Actual Mean Profile (m)
Dry: above water level	± 0.3 Dn 50	+ 0.35 Dn 50 -0.25 Dn 50
Less than 5m	± 0.5 Dn 50	+ 0.6 Dn 50 - 0.4 Dn 50
More than 5m	± 0.5 Dn 50	± 1.0m

Where, Dn50 is the diameter of the cube with equivalent volume to the block with median weight..

612.03.6.4 Surveying technique

a. Procedure: Carry out survey measurements using a probe with a spherical end of diameter 0.5 (Dn 50). For land-based survey this shall be connected to a staff; for underwater survey it will be a weighted ball on the end of a sounding chain.

b. Survey intervals: Carry out measurement profiles at intervals of 25m along the length of the structure and at intervals of 3m across the measurement profile.

c. Diving inspection: Make provisions for diving inspections for any part of the structure where achievement of tolerances may otherwise appear in doubt..

612.03.6.5 Storage, handling, and laying of geotextiles:

a. Store and Handle geotextile in accordance with ASTM D4873-02.

b. Geotextiles placement: Use overlaps in accordance with manufacture requirements, and in no case less than 50 cms.

c. Geotextile exposure following placement: Place bedding layer as soon as possible after placement of the geotextile, according to the approved method statement of the construction procedure.

d. Seams: Where seams are required, make them in accordance with the manufacture requirements. All seams shall be subjected to the approval of the Engineer.

e. Damage to Geotextile: Remove and replace any damaged or punctured section before or after laying.

612.04 MEASUREMENT AND PAYMENT

612.04.1 Basis of Measurement and Payment

The method of measurement and payment for earthworks shall be as Clause 208.08 of Section 2 (Earthworks) of these Specifications, for culvert furniture as Clause 1704.07.1.E of Section 17 (Utilities Structures) of these Specifications and for plain and reinforced concrete shall be as specified herein. Payment will be made under Section 6 of the Bills of Quantities.

Plain concrete shall be measured by cubic metre. Reinforced concrete shall be measured by the cubic meter of concrete including reinforcement. Payment shall be at the rate inserted in the Bills of Quantities, which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the works including mixing, transporting and placing the concrete, vibrating as necessary, erecting and removing form work, curing, testing samples and test panels, reinforcement and all other incidental works in connection with the construction.

Connection works between new and existing box culverts shall be numerated regardless of size. Payment shall be at the rate inserted in the Bills of Quantities which rate shall include but not by way of limitation, all labour, material, equipment, breaking the existing concrete, cleaning and exposing the reinforcement for sufficient lap length, fixing reinforcement and formwork, making good joints, and all associated work necessary to complete the works.

Erosion protection measures to the area downstream of the sea outfall structure should be measured separately for each item as stated below and are also deemed to include all surveying works and seabed sounding, clearance of the seabed; removal of unsuitable material, objects or obstructions, inspection for and relocation of any existing underwater services, protection from sea action, losses due to erosion or damage, losses/damage due to wave conditions which may occur during the Contract period including the Period of Maintenance.

a. Underlayer, rock armour, Quarry run and bedding layer:

    1. The volume measured for underlayer, rubble base (Quarry run), rock armour, and bedding layer, is the volume measured to the lines and levels as shown on the Drawings. It shall be measured in cubic metres.

    2. The rates for underlayer, quarry run, rock armour and bedding layer are deemed to include:
        i. all costs of obtaining stone/rockfill,
        ii. crushing, screening and testing to achieve the specified gradings,

iii. transporting to site and placing in stockpiles (as required) at the work locations including maintenance and relocation of stockpiles (as required),
iv. Taking from stockpiles at the work locations, placing, compacting and for all costs of trimming the underlying material to receive the stone/rock.

b. Dredging for embedded toe protection:

1. Dredging is measured in cubic metres as the volume to the lines and levels as shown on Drawings. Rates inserted by the Contractor shall be deemed to include for all over cutting in width and depth and for sweeping the dredged areas.

2. Dredging is deemed to include:

i. Supply and installation of all plant and equipment required to carry out dredging,
ii. Dredging in sand, clay, or any material whatsoever encountered except rock. If rock was encountered in seabed the berm/toe should be placed directly on seabed,
iii. pumping/transportation of dredged material to whatever distance required,
iv. Disposal of dredged material to approved locations.

c. Fabrics and membranes (Geotextile):

1. Fabrics and membranes (geotextile) are measured in square meters of the area covered. No deduction is made for voids not exceeding 1.00 m2.

2. Work is deemed to include:
i. all costs of obtaining fabrics and membranes,
ii. all costs of sampling and testing of fabrics and membranes,
iii. horizontal, sloping, vertical and curved work,
iv. work of any width or girth,
v. Extra material for lapping and jointing.

612.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
612.1	Earthworks	cu.m
612.2	Extra over for rock excavation	cu.m
612.3	Plain concrete	cu.m
612.4	Reinforced concrete (class)	cu.m
612.5	Covers and frames	nr
612.6	Mud buckets	nr
612.7	Ladders	nr
612.8	Connection of new box culvert to existing	nr
612. 9	Sea outfall erosion protection works - underlayer	cu.m
612. 10	Sea outfall erosion protection works - rock armour	cu.m
612. 11	Sea outfall erosion protection works - Quarry run	cu.m
612. 12	Sea outfall erosion protection works - bedding layer	cu.m
612. 13	Sea outfall erosion protection works - dredging	cu.m
612. 14	Sea outfall erosion protection works - Geotextile	sq.m

613 - PROTECTION OF STRUCTURES

613.01 GENERAL

All structures under Clauses 610,611, 612 of these Specifications shall be protected as specified under Clauses 516 and 517 of Section 5 (Concrete Works) of these Specifications.

Structures situated wholly or partly below the ground water level shall be protected by membrane as specified in Clause 516 o Section 5 (Concrete Works) of these Specifications. The membrane shall be extended 1metre

above the groundwater table. Protective membrane shall be used in all cases where structures are situated in contact with agricultural soil and shall extend to 100mm above the top level of the agricultural soil. Material and application shall be in accordance with Clause 516 of Section 5 (Concrete works) of these Specifications.

Structures situated wholly above the ground water level shall be protected by two coats of painting as specified in Clause 517 of Section 5 (Concrete Works) of these Specifications and as amended herein.

Two coats of bituminous protective painting shall be applied to all concrete surfaces in contact with soil and not protected by membrane. Protective painting shall be terminated at finished ground level. Material and application shall be in accordance with Clause 517 of Section 5 (Concrete Works) of these Specifications.

613.01.1 Concrete Protection against Aggressive Environment

Refer to Section 5 of these Specifications regarding the requirements under this Clause..

613.02 INTERNAL PROTECTIVE COATINGS FOR CULVERTS, ACCESS CHAMBERS AND MANHOLES

All internal surfaces of culverts, manholes and access shafts shall be protected by a painted coating system as described hereunder.

613.02.1 Coating Material

The coating material shall be one of the following:

1. Epoxy: This shall have the following minimum properties:

   – Water absorption: Less than 1% weight gain after 7 days as per ASTM D 570.
   – Tensile strength: 120 kg/cm2 when tested per ASTM D 638
   – Elongation at break: Minimum 1% when tested per ASTM D 638

2. Hydrophobic Polyurethane Elastomer: This shall have the following minimum properties:

   – Water absorption: Less than 1% weight gain after 7 days as per ASTM D 570.
   – Tensile strength: 120 kg/cm2 when tested per ASTM D 412
   – Elongation at break: More than 100% when tested per ASTM D 412
   – Tear strength: 35 kN/m when tested per ASTM D 1004

613.02.2 Primer

Primer shall consist of solvent thinned unpigmented, unfilled epoxy aliphatic amine or epoxy aromatic amine or as prescribed by the manufacturer.

613.02.3 Surface Preparation

The surface of concrete shall be cleaned thoroughly, fair faced free of blow holes, pits and voids. The surface shall be roughened with epoxy amine filler/sand blasting/pressure water wash on needle gun.

613.02.4 Application

The Primer shall be applied over the whole area to be coated. The primer shall soak into concrete and shall not leave a resin rich layer on the surface. Primers containing fillers or pigments shall not be used. A minimum of 24 hours shall be elapsed before filling the surface.

Two coats of a solvent free system as specified above shall be applied and sealed. Dry film thickness shall be specified by the manufacturer or 550 microns, whichever is higher.

613.03 CONSTRUCTION JOINTS & EXPANSION JOINTS

Plain bonded construction joints and expansion joints are to be provided for the box culvert in accordance with the Drawings.

613.04 MEASUREMENT AND PAYMENT

613.04.1 Basis of Measurement and Payment

The method of measurement for concrete protection works shall be as specified in Clauses 516.06 and 517.05 of Section 5 (Concrete Works) of these Specifications.

Measurement of protective coating and painting of internal concrete surfaces shall be by the square metre of developed surface areas covered by the coating.

Payment for the above work shall be made under Section 6 of the Bills of Quantities. The rate shall include but not by way of limitation all labour, plant, materials, equipment and everything necessary for the proper execution of this work, including surface preparation, primer and protection.

There shall be no separate measurement and payment for the furnishing and installation of joints in Concrete Works, the cost of which will be deemed to the included in the rates for the various concrete items in the Bills of Quantities.

613.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
613.1	Concrete protection by membrane	sq.m
613.2	Concrete protection by painting	sq.m
613.3	Protective coating and painting of internal concrete surfaces	sq.m

614 - PIPELINE CONSTRUCTION BY NON-DISRUPTIVE METHODS (MICROTUNNELLING)

614.01 GENERAL

The Contractor shall perform horizontal boring in accordance with the provisions of this Section. Horizontal boring is defined as trenchless construction techniques that do not involve personnel entry into the bored excavation for the carrier pipe and casing pipes. The Contractor shall be responsible to determine the best method to employ for horizontal boring from the methods described in this Section. The following factors shall be considered by the Contractor in selection of the horizontal boring method:

1. Types of soils anticipated including the percentages of gravels, cobbles, and boulders.
2. Presence of groundwater.
3. Length of the bore.
4. Proximity of existing utilities.
5. Possible impacts on traffic.
6. Space availability for operation of equipment and staging.
7. Required grade and alignment accuracy.
8. Environment conditions and the impact of the method selected on those conditions .
9. Possibility or probability of obstacles in the planned alignment.
10. The type and size of the carrier pipe or casing to be installed.

614.02 REFERENCES

a. ASTM A 283 Specification far Low and Intermediate Tensile Strength Carbon Steel Plates.
b. ASTM C 150 Specification for Portland Cement
c. ASTM C 869 Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete
d. AWWA C 213 Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
e. BSEN 295-7 Specification for Vitrified Clay Pipes and Joints for Pipe Jacking
f. DIN 54815 Part 1 & Part 2. Pipes Made of Filled Polyester Resin Moulding material (Polymer Concrete Pipes).
g. BS 591I:120:1989 Specification for Precast Reinforced Concrete Jacking Pipes.

614.03 DEFINITIONS

The following definitions shall apply to words and phrases utilised herein:

1. "Microtunnelling": A variation of pipe jacking in which a remotely operated microtunnel boring machine (MTBM) performs the excavation of the bore hole. The MTBM is articulated; laser guided and maintains full cutting face control. Piping is continuously jacked behind the MTBM and accurate grade and alignment are achieved.

2. "Face Control": Complete mechanical support of the excavated face at all times.

3. "Earth Pressure Balance": Pressure applied to the cutting face equals the pressure of the earth against the cutting face.

4. "Drill String": A series of joined individual pipes which is used to advance the excavation equipment.

5. "Annular Space": The void between the outside diameter of the installed casing pipe and the outer limits of the bore being excavated for the casing pipe. The annular space also refers to the space between the casing pipe and the smaller diameter carrier pipe installed within the casing.

6. "Hydraulic Fracturing": Shall mean fractures produced by pressurised drilling fluids or grout in weak or unconsolidated areas of the soil matrix resulting in excessive fluid loss or upwelling of fluid to the surface.

614.04 SUBMITTALS

A. Shop Drawings

The Contractor shall submit shop drawings for approval of the Engineer. Submittals shall include the following, as applicable:

1. Carrier pipe and casing materials, including the diameter, wall thickness, specifications, relevant data, and pipe class.

2. Installation schedules for excavation, pipe installation, backfill, grouting, and related horizontal boring operations.

3. Data on lubricants (including Material Safety Data Sheets) proposed for installation.

4. Locations, dimensions, and shoring plans and sections for boring and receiving shafts, including the method of excavating, shoring, bracing the shaft and thrust block design.

5. Manufacturers' data sheets and specifications describing in detail the system to be used.

6. Layout and work plans of the proposed horizontal boring method.

7. Traffic control plans, in conformance with Section 18 (Maintenance and Protection of Traffic) of the Specifications.

8. Plans for protecting existing utilities in proximity to horizontal boring operations. Such plans shall be in accordance with the requirements of relevant authorities.

9. Plans for monitoring ground surface movement (settlement or heave) due to construction. The plan shall address the method and frequency of survey measurement. As a minimum, the plan shall measure the ground movement of all structures, roadways, parking lots, and any other areas of concern within 10.0m on both sides of all horizontal pipelines at a maximum spacing of 30.0m along the pipeline route, or as required by the Engineer. Allowable movements / measures to be taken. (if exceeded, should be addressed).

10. The Contractor shall submit a dilapidation survey report for all structures, roads and utility networks that might be affected by the construction works carried out by the Contractor, within the zone of influence.

B. Permits

The Contractor shall obtain necessary permits from concerned authorities having jurisdiction and furnish two copies to the Engineer before the start of the work.

C. Certifications

The Contractor shall furnish a certified affidavit of compliance from accredited testing agency for all pipe and other products or materials under this Section, including physical and chemical properties of all steel. All expenses incurred in making samples for certification of tests shall be borne by the Contractor.

D. Qualifications

1. Horizontal boring shall be performed by a qualified subcontractor to be approved by the Engineer. The subcontractor shall have successfully completed at least two previous horizontal boring operations of similar length and diameter.

2. The Contractor may have been prequalified to undertake this specialist work and may decide to undertake the work by himself, rather than employ a specialist subcontractor.

   In either case the Contractor shall submit documentation for the staff he proposes to employ on this work, to demonstrate their competence to undertake such work. Full details of qualifications, training and experience, shall be submitted, for approval by the Engineer. This shall include a Certificate of Competence for the MTBM operator, awarded by the MTBM manufacturer.

3. The Contractor shall provide descriptions of similar projects, including references, where the subcontractor responsible for horizontal boring has successfully used the proposed horizontal boring system.

E. Submittals for Safety

Procedures to meet all applicable local safety requirements. These procedures shall be submitted for a record purpose only and will not be subject to approval by the Engineer. As a minimum, the Contractor shall provide the following:

1. Protection against soil instability and groundwater inflow.

2. Safety for shaft access and exit, including ladders, stairs, walkways, hoists, traffic barriers, accidental or unauthorised entry and falling objects.

3. Protection against mechanical and hydraulic equipment operations and for lifting and hoisting equipment and material.

4. Ventilation and lighting.

5. Monitoring for hazardous gases.

6. Protection against flooding and means of emergency evacuation.

7. Emergency protection equipment.

8. Safety supervising responsibilities.

F. Submittals for Microtunnelling and Auger Boring

The Contractor shall submit the following items for microtunnelling and auger boring. Approval of the following submittals shall be obtained before ordering pipe materials or starting operations:

1. Spoil disposal method, including all materials encountered in the construction of the horizontal boring and associated shafts.

2. Maximum anticipated jacking loads and supporting calculations.

3. Methods to control and dispose of groundwater.

4. Grade and alignment control systems.

5. Intermediate jacking station locations and design.

6. Lubrication and/or grouting system.

7. Annular space grouting plan.

8. Contingency plans for correction of the following potential conditions:

    a. Damage to pipeline structural integrity and repair.

    b. Loss and return to line and grade.

    c. Loss of ground.

614.05 QUALITY ASSURANCE

A. Notification

The Contractor shall provide a minimum of 3 days advance notice before the start of excavation or boring operations. No work shall be performed without prior approval of the Engineer.

B. Superintendent

The Contractor shall also provide an experienced on-site superintendent to direct the Work. The superintendent shall be on site throughout the operations and shall have at least five years previous experience in directing equivalent installations and shall require Engineer's approval.

614.06 SAFETY

Except as otherwise indicated, the following codes apply to the work described herein:

1. The Contractor shall provide flagmen, barricades, lights, warning signs, ventilation, air quality and other safety devices and equipment as may be required, to ensure the safety of all people who may enter the area. The Contractor shall establish a procedure to log persons into and out of the bore shaft and shall take necessary steps to prevent unauthorised entry.

2. All boring and jacking work shall be performed in accordance with all applicable safety provisions in the Reference Specifications and Standards identified herein.

614.07 EXISTING CONDITIONS

A. Subsurface Conditions

The Engineer will make available to the Contractor existing subsurface information. All such information will be given without any liability on the Employer / Engineer for its accuracy and any inferences drawn there from, shall be at the Contractors own responsibility. Additional subsurface investigations deemed necessary by the Contractor to complete horizontal boring work shall be conducted at no additional cost to the Employer. Copies of all additional subsurface reports obtained by the Contractor shall be provided to the Engineer.

B. Subsurface Test Samples

The Contractor shall collect subsurface test samples within 6metres horizontally of the centerline of the proposed conduit location when practicable. Subsurface samples shall be collected to a minimum depth of one pipe diameter below the proposed conduit invert elevation. Test samples shall be collected at a maximum of 60m intervals.

C. Utilities

The Contractor shall conduct an investigation to identify and locate all underground utilities within 6.0m of each side of the centerline of the proposed conduit alignment. Utility location and depth shall be positively verified by trial pits. The Contractor shall take all necessary precautions to prevent damage to existing utilities, which could result from trenchless excavation activities. The Contractor shall give special consideration to oil lines, electric and communication cables by submitting a report acknowledging the proximity of these utilities and actions to be taken to avoid damage to them. The Contractor shall repair, replace, or compensate the respective owners for any damage to permanent facilities due to negligence or lack of adequate protection. These facilities include utilities, structures, trees, shrubs and other permanent objects.

614.08 PRODUCTS PIPES FOR MICROTUNNELLING

614.08.1 General

A. Materials

1. Pipes: Shall be of sufficient thickness and axial strength to withstand the forces encountered during installation and operation.

   To avoid project delay the Contractor shall contact in advance with the pipe manufacturers to assure the supply of pipes to the site on time, particularly, the pipes that require special moulding in the production process and such supply periods shall be allowed for in the Contractor's Program of Works.

2. Pipes shall be either, Vitrified Clay, Polymer Concrete or Precast Reinforced Concrete Jacking Pipes.

   a. Vitrified Clay pipes (for diameter up to 600mm) shall be in accordance with BSEN 295 Part 7, January 1993 or latest revision.

   b. Polymer Concrete Jacking pipes shall be in accordance with DIN 54815, Part 1 Part 2.

   c. Precast reinforced concrete jacking pipes shall be in accordance with BS EN 1916 and BS 5911-1.

All pipes to be installed by micro tunnelling must be structurally suitable for both the permanent loading at the installation depth concerned when in service under the ground conditions encountered and for the temporary loading imposed during installation. Full details of the proposed design, manufacturing and testing of the pipes will be required for approval by the Engineer, prior to manufacture.

Reference should be made to the appropriate chart on the Drawing as a guide to pipe strength requirements in relation to depth of installation and ground conditions in which the pipeline is proposed for installation when pricing. No liability for additional costs will be accepted by the Employer should pipes of a higher strength class be found necessary for installation during approval of the pipe design than was allowed by the Contractor when pricing his tender. The Contractor will be required to execute the work using appropriate strength pipes at the rates and prices inserted in the tender.

614.08.2 Vitrified Clay Pipes

A. General

VCP pipes for micro tunnelling shall be as per BSEN295 Part 7, January 1993 or latest version. All VCP (Vitreous Clay Pipes) and fittings shall be of one class; designated extra strength; of the best quality; vitrified; homogenous in structure; thoroughly burned throughout the entire thickness; impervious to moisture; sound and free from cracks, blister, broken extremities, or other imperfections. Pipe ends shall be square with the longitudinal axis and concentric with the barrel of the pipe. The thickness of the shell and the dimensions of the annular space shall be within the permissible limits as specified in BSEN 295 and ASTM C1208, for the size of pipe specified on the Drawings.

B. Pipe Marking

All pipes and fittings shall be clearly marked with the name of the manufacturer or with a trademark, location of the manufacturing plant and with the size and strength of the pipe as shown on the Drawings.

C. Testing

1. Before being used in any work under these Specifications, the pipe shall be subjected to hydrostatic pressure test and loading test, to ensure compliance with the Specifications. These tests shall be carried out by an approved testing laboratory.

2. The pipes selected for testing shall be delivered to the place and at the time designated by the testing laboratory. All cost associated with the selection, transportation and testing of the pipes shall be paid by the Contractor.

3. The testing laboratory shall select, at random, not less than 1% of the number of pipes in each size of pipe specified, for testing as specified herein.

4. The specimens selected for testing shall be sound pipe having dimensions consistent with these Specifications. The lot, or lots, from which the test samples are taken, shall be sufficient to fill the entire order for that size of pipe used in the work in the Contract. If the pipes pass the tests, they shall be so designated and marked.

5. All pipes shall be subject to inspection by the Engineer, at the factory, trench, or other point of delivery. The purpose of the inspection shall be to identify any pipe which, independent of the tests herein specified, fails to conform to the requirements of these Specifications, or which may have been damaged during transportation, or in subsequent handling.

6. In lieu of the standard ASTM absorption test, the ASTM C 301 hydrostatic pressure may be substituted. The hydrostatic pressure test shall precede the loading test by not less than one hour and by not more than three hours and shall be applied to all the specimens received for test, in each size of pipe.

7. The loading shall be the 3-edge bearing test. The loading tests shall conform to the applicable provisions of BSEN 295 or ASTM C 301 and shall be applied to all specimens selected for testing, except that loading to test the ultimate strength will not be required.

8. If all of the designated percentage or number of the specimens tested, meet the requirements of the tests, then all the pipes in the lot, shipment or delivery corresponding to the sizes and classes so tested shall be considered as complying with the tests. However, if 10% or more of the specimens tested fail to meet the test requirements, or if more than one specimen fails to meet the test requirements when the number to be tested is less than ten, then a second selection of pipes shall be made for that test.

9. The number of specimens to be tested in the second selection of pipe shall be five for each specimen of the first selection that failed to meet the requirements.

10. If 90% or more of the specimens tested, including those first tested, meet the test requirements, all the pipes in the consignment, shipment or delivery, corresponding to the sizes and classes so tested, shall be considered as complying with that test. Otherwise, all pipes of these sizes and classes shall be rejected.

D. Causes for Rejection

The following imperfections in a pipe or special fitting shall be considered damaged and cause for rejection, without consideration of the test results specified above.

1. A single crack in the pipe barrel.

2. Surface imperfections, such as lumps, blisters, pits, or flakes, on the interior surface of a pipe or fitting.

3. When the bore of the pipe varies from a true circle by more than 2% of its nominal diameter.

4. If it is designated to be straight and it deviates from a straight line by more than 3mm per metre length. The deviation shall be measured from a straight edge, at a point midway between the ends of the pipe.

5. A pipe joint with a piece broken from either end.

6. Pipe joints which have tramp clays or other foreign matter flushed permanently to the exterior or interior of the pipe or fittings.

E. Joints

1. All VCP fittings shall be furnished with flush joints provided with a compression ring, sealing element and sleeve, meeting all the requirements of BSEN 295.

2. The compression ring shall be capable of distributing evenly, the jacking forces that develop during installation.

3. The joint sleeve shall be Type 316 stainless steel, unless otherwise specified. Sealing compounds shall conform to Tables nos. 7 and 8 of ASTM C1208.

4. Where pipes of different manufacturers are to be joined together, use an adapter pipe with the proper matching joint on each end for the respective manufacturer. Hot poured joints on concrete encasement of plain end joints are not permitted.

614.08.3 Polymer Concrete Pipes

Polymer Concrete Jacking Pipes shall be in accordance with DIN 54815, Part 1 Part 2.

614.08.4 Precast Reinforced Concrete Jacking Pipes

Precast reinforced concrete jacking pipes shall be in accordance with BS EN 1916 and 5911-1**.**

For all types of pipes, full details of the pipe design, manufacturing and testing of pipes will be required for approval by the Engineer prior to manufacture and supply to the Site.

614.09 LUBRICANTS

Lubricants: Water shall be used as a lubricant for jacking operations and may contain clay based and/or polymer additives to reduce the skin friction of the installed pipe.

614.10 GROUT

Where grouting is required, it shall be in accordance with the Specifications.

The Contractor shall submit samples of materials methodology and equipment to be used for the approval of the Engineer.

614.11 EXECUTION

614.11.1 General

A. General Requirements

The Contractor shall comply with the lawful requirements of affected Government agencies, public utilities and other entities. Trenches, shafts or pits in public streets shall not be open for extended periods of time according to the approved work plan.

B. Traffic Control

Excavation within the public right-of-way shall be subject to the conditions of the approved traffic control plan.

C. Boring and Receiving Pits

The Contractor shall comply with the provisions of Clause 614.11.2 below.

D. Line and Grade

The Contractor shall maintain the specified line and grade of the pipe. The Contractor shall provide and maintain instrumentation to monitor the borehole position at all times and shall maintain a record of the installation process. The Engineer shall have access to the instrumentation and records at all times.

E. Settlement

The Contractor shall prevent settlement of overlying structures or other damage due to the boring operations.

F. Countermeasures

Appropriate equipment shall be provided to counter conditions which can cause delay such as groundwater, running sand, boulders, etc. The Contractor shall develop and submit an acceptable contingency plan to address such conditions. The Contractor shall be alert at times to abnormalities in installation process. The Engineer shall be notified immediately if anomalies are encountered.

G. Permits

All permits related to the horizontal boring shall be obtained by the Contractor. The Contractor shall abide by all permit conditions.

H. Field Testing

Refer to Soils Report to be made by the Contractor before microtunnelling works.

I. Noise

Construction noise greater than 70db will not be allowed.

614.11.2 Boring and receiving shafts

A. Sheeting, Shoring and Bracing

Shafts shall be constructed to accommodate boring equipment and provide safe working space around the equipment as recommended by the equipment manufacturer including sheeting, shoring, and bracing for boring and receiving shafts and shall have adequate shoring to prevent wall collapse or ground movement in the vicinity of the shaft.

B. Personnel

No personnel shall be present in the receiving pits when entry of the boring device is expected.

C. Dewatering

When installed below the water table, waterproof sheet piles and / or a dewatering system shall be employed to keep the shaft dry at all times. Dewatering shall conform to the requirement of Clause 102.13 of section 1 (General) of these Specifications. Measures shall be taken to prevent surface runoff from entering the shaft.

When excavation is carried out in water-bearing ground, regular checks shall be made, in conjunction with the Engineer, to compare the volume of material removed with the calculated volume, as a safeguard against excessive loss of material beyond to shaft dimension.

D. Foundation

Boring pits shall have a foundation of crushed stone or equivalent to provide a base for support and alignment of the boring equipment. Thrust blocks shall be perpendicular to the proposed bore alignment and be designed to support the maximum jacking pressure of the proposed jacking system. If concrete thrust block or treated soil is used as the jacking restraint, no jacking shall be performed until the required strength has been attained. Jacking forces shall be distributed evenly over the thrust blocks. Bearing blocks of timber or structural steel shall also be used to distribute jacking forces evenly around the perimeter of installed piping or casings.

E. Backfilling Shafts

All shafts shall be backfilled upon completion of operations in accordance with the requirements of Section 2 (Earthworks) of these Specifications. All equipment, shoring, bracing and rubbish shall be removed from the job site.

614.11.3 Drilling fluids and slurries

a. The following requirements apply to the use of drilling fluids and their additives.

   1. Drilling fluid pressures shall be limited to those necessary and shall be controlled to avoid or minimise hydraulic fracturing or over excavation. If hydraulic fracturing or excessive loss of fluid is discovered, the process shall be halted until actions are taken to control the losses.

   2. Drilling fluids and cuttings shall be recovered and separated and the drilling fluid reused. Direct disposal of drilling fluids may be permitted, with the approval of the Engineer. The Contractor shall be responsible for the disposal of excavated material as well as excess drilling fluid, water, trash, and waste. Containment barriers shall be used to prevent drilling fluid run off the construction Site and

frequent inspections along the bore path for upwelling drilling fluid shall be conducted. Cleanup of any inadvertent returns shall be performed in a timely manner.

614.11.4 Microtunnelling

A. General

Unless otherwise indicated, the minimum depth of cover to the top of the installed pipe or casing shall be 1.5 times the outside diameter of the pipe or casing being installed or 2metre, whichever is greater. The minimum depth of cover may be reduced with the permission of the Engineer. This 2metre minimum cover shall extend in all directions around the pipe being installed.

B. Settlement

Settlement or heave at the ground surface during and after construction along the centerline of the conduit installed shall not exceed 12mm, unless otherwise specified.

C. Equipment

The MTBM shall be capable of installing the pipe while being compatible with the anticipated soil and geotechnical conditions. It shall be capable of installing a length of pipeline (i.e. from manhole to manhole) of 125m-130m. The MTBM cutter face shall at all times be capable of supporting the full excavated area without the use of ground stabilisation and have the capability of measuring the earth pressure at the face and setting a calculated earth balancing pressure. The maximum radial annular space shall not exceed 25mm, unless otherwise specified. The MTBM shall be capable of controlling shield rotation by means of a bi-directional drive on the cutter head or by use of mechanical fins or grippers. The MTBM shall be mechanically articulated to enable remotely controlled steering of the shield. The MTBM shall control groundwater during excavation without the use of external dewatering equipment. The measuring and balancing of earth and groundwater pressure shall be achieved by use of a slurry or cased auger system. The system shall be capable of incremental adjustments to maintain face stability for the soil conditions encountered.

D. Jacking Equipment

The main jacks shall be mounted in a jacking frame and located in the jacking shaft. The MTBM shall be moved forward by the jacks advancing a successive string of connected pipes toward a receiving shaft. Intermediate jacking stations may be used for long drives where frictional forces would cause the maximum allowable jacking force to be exceeded. The intermediate jacking station shall employ a steel jacket or other suitable means to prevent soil intrusion into the conduit. Jacking forces at the intermediate jacking station shall be continuously monitored during jacking operations. The maximum jacking capacity used shall not exceed the allowable jacking capacity of the pipe, which has a minimum factor of safety of 2.5.

E. Excavation Controls

The control equipment shall integrate the method of excavation and removal of soil and its simultaneous replacement by a pipe. As each pipe section is jacked forward, the control system shall synchronize spoils removal, excavation, and jacking speeds. Operations shall be stopped when they result in pipe damage or any surface disruption. The Contractor shall propose immediate action for review and approval by the Engineer, to remedy the problem at no additional cost.

F. Automated Spoils Transportation

The MTBM shall include one of the following:

1. Slurry System

The system shall be capable of measuring earth and groundwater pressure and making the adjustments required to counter-balance the earth and groundwater pressure to prevent loss of slurry or uncontrolled soil and groundwater inflow.

a. The slurry pressure at the excavation face shall be controlled by use of slurry pumps

b. A slurry bypass method shall be included to allow for a change in direction of flow to be made and/or isolated.

c. A separation process shall be provided, properly sized for the tunnel being constructed, the soil type being excavated, and the workspace available at each area. This is used to separate the spoil from the slurry, so that slurry may be returned to the cutting face for reuse.

d. The composition of the slurry shall be monitored to maintain the slurry density and viscosity limits as specified in the approved submittals

2. Cased Auger System

The cased auger system shall monitor and continuously balance the soil and groundwater pressure. The system shall be capable of adjustments required to maintain face stability for the particular soil condition to be encountered, to prevent loss of soil or uncontrolled groundwater inflow.

a. The system shall maintain the pressure at the excavation face by controlling the volume of spoil removal, with respect to the rate of advance. The system shall monitor the speed of the rotation of the auger and the amount of water added.

b. The Contractor shall submit an evaluation of equipment's ability to balance earth and water pressure at the face, stability of the soils and the significance of the groundwater present.

G. Active Steering Controls

A remotely controlled steering mechanism shall be provided that allows for the operation of the system without the need for personnel to enter the micro tunnel. The steering information shall be monitored and transmitted to the operation console. The minimum steering information available to the operator on the control console shall include the position of the shield relative to the design reference, roll, inclination, attitude, rate of advance, installed length; thrust force and cutter head torque.

H. Guidance / Monitoring Equipment

The MTBM display equipment shall continuously show and automatically record the position of the shield with respect to the project design line and grade. The automated recording system shall include real time information such as earth and ground pressure, roll, pitch, attitude, rate of advance, installed length, cutter head torque, jacking loads, slurry pressure, slurry flow and slurry valve positions. Line and grade adjustments of the MTBM shall be controlled by an operator or by an automated guidance system at the discretion of the Contractor. The actual position of the MTBM shall be continuously related to a design reference (e.g.; by a laser beam transmitted from the jacking shaft along the line of the pipe to a target mounted in the shield). The line and grade tolerances of pipe installed shall be 25mm on grade and 32mm in line between shafts, unless otherwise specified or approved by the Engineer. The rate of return to line and grade shall not exceed 1:3000, unless otherwise specified.

I. Intermediate Shafts

If an intermediate shaft is requested, the Contractor shall obtain a written approval from the Engineer. The intermediate shaft shall not be located in areas prohibited in the Contract Documents. The Contractor's request shall include all necessary permits and approvals, minimise public inconvenience and minimise impacting existing facilities.

J. Annular Space Grouting

The annular space created by the over cut of the MTBM in excess of 20mm shall be filled with an approved material, unless otherwise specified. When grouting is specified, pressure-injected grout shall fill voids outside the limits of the excavation created by caving or collapse of earth cover over the excavation. The Contractor shall furnish and operate suitable equipment for any required grouting operations depending on the condition of the application. The grouting operation shall not damage adjacent utilities or other properties. Grout shall be injected at a pressure that will not distort or imperil any portion of the work or existing installations or structures.

K. Piping

The pipe manufacturer's design jacking loads shall not be exceeded during the installation process. The pipe shall be designed to take full account of all temporary installation loads. Damaged pipe shall be jacked through

to the reception shaft and be removed. Other methods of repairing the damaged conduit may be used, as recommended by the manufacturer and approved by the Engineer.

L. Field Testing

Two hydrostatic tests shall be performed; one at the surface after pipeline fabrication and the other after the pipe has been placed in its final position.

614.12 MEASUREMENT AND PAYMENT

614.12.1 Basis of Measurement and Payment

Measurement for pipe installation by NDM shall be by metre run of each group of pipes to be classified based on material and diameter. Payment shall be at the rate inserted in the Bills of Quantities, which rate shall include but not limited to design the whole operation and submittal of shop drawing for Engineer's approval, furnishing all labour, materials, equipment necessary boreholes and soil investigation and for doing all work involved in installing the pipes. The rates shall also include for excavation and construction of boring and receiving shafts, dewatering if required including supporting and protecting all utilities affected by the work.

614.12.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
614.1	Pipe supply and installation by NDM (material, diameter)	m

SECTION 7: TRAFFIC MARKINGS & SIGNS

700 - GENERAL

700.01 GENERAL

This Section covers the Specifications of materials, testing, equipment, method of execution of the works, method of measurement and payment for traffic markings and signs.

700.02 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

A 123	Zinc (Hot-Galvanised) Coatings on Iron and Steel Products
A 653	Steel Sheet, Zinc-Coated (Galvanised) or Zinc Iron Alloy-Coated (Galvannealed) by the -Dip Process
C 373	Water Absorption, Bulk Density, Porosity and Apparent Specific Gravity of Fired Whiteware Products
C 424	Grazing Resistance of Fired Glazed Whitewares by Autoclave Treatment
D 36	Test Method for Softening Point of Bitumen (Ring and Ball Apparatus)
D 523	Specular Gloss
D 868	Bleeding of Traffic Paint
D 869	Settling of Traffic Paint
D 1155	Roundness of Glass Spheres
D 1214-04	Standard Test Method for Sieve Analysis of Glass Spheres.
D 2028	Cutback Asphalt (Rapid-Curing Type)
E 1347	Color and Color Difference Measurement by Tristimulus (Filter) Colorimetry
G 152-06	Operating Light and Water Exposure Apparatus (Carbon-Arc Type) for Exposure of Non- Metallic Materials
G153-04	Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials.

AASHTO

M 247	Glass Beads Used in Traffic Paint
M 249	White and Yellow Reflective Thermoplastic Material

BS

BS 381C	Specifications for Colors for Identification Coding and Special Purposes
BS EN12899	Road Traffic Signs and Internally Illuminated Bollards
BS EN 1427	Softening Point of Bitumen (Ring and Ball) Part 58
BS EN 610	Ingot Tin Chemical Properties
BS 3262-3	Hot-Applied Thermoplastic Road Marking Materials
BS 6088	Solid Glass Beads for Use With Road Marking Compounds and for Other Industrial Uses
BS 5400-6	Steel, Concrete and Composite Bridges, Specifications for Materials and Workmanship, Steel

Federal Test Method Standard

No. 141	Paint, Varnish, Lacquer and Related Materials. Method of Inspection, Sampling and Testing

Federal Specifications

TT-P-85 Paint, Reflectors etc.

Federal Standard

595 Paint Color

Manual

Kuwait Manual on Traffic Control Devices

701 - THERMOPLASTIC PAVEMENT MARKING AND TRAFFIC PAINT

701.01 THERMOPLASTIC PAVEMENT MARKING (STRIPING MATERIAL)

White or yellow thermoplastic for use as reflective pavement marking or striping material on bituminous and/or cement concrete pavement shall consist of materials containing glass beads, so manufactured as to be applied to the pavement surface in a molten state by mechanical means. With surface application of glass beads at the specified rate. Upon cooling to normal pavement temperature, this material shall produce an adherent stripe of specified thickness and width and shall be capable of resisting deformation by traffic.

Unless otherwise shown on the Drawings, white and yellow reflective thermoplastic striping materials shall meet the requirements of AASHTO M 249, and the additional requirements set out below.

701.02 MATERIAL REQUIREMENTS

701.02.1 Specific Gravity

The material shall have a specific gravity of not more than 2.15.

701.02.2 Aggregate

The aggregate shall consist of light colored silica sand, calcite, quartz, calcined flint, or other approved aggregate.

701.02.3 Pigment and Extender

For white markings, the pigment shall be titanium dioxide (antase or rutile) and its content shall be such as to give a minimum luminance factor for the material of 75% in accordance with Section 4.3.1 of AASHTO M 249 White lines shall remain free from discoloration by normal traffic.

Unless otherwise shown on the Drawings, the pigment for yellow markings shall be a lead chromate which is sufficiently color stable when heated in accordance with Section 4.3.1 of AASHTO M 249..

The extender shall be calcium carbonate prepared from natural chalk, silica flour or other approved material.

701.02.4 Binder

The binder shall be hydrocarbon. The viscosity and wetting properties of the molten binder at the spraying temperature will be such as to give a composition of satisfactory spraying properties.

701.02.5 Reflectorization

Reflectorization shall be by glass beads as specified in Clause 702 herein.

701.03 COMPOSITION OF MIXTURE

The proportions of the constituents of the mixed materials as found on analysis shall comply with the requirements of Table 701.03.

Constituent	Percent by mass of total mixture	
	White	Yellow
Binder	18 (min)	18.0 (min)
Glass beads	30-40	30-40
Titanium Dioxide	10.0 (min)	-
Calcium Carbonate and Inert Fillers	42.0 (max)	See note 1
Yellow Pigments	-	-

Note 1: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, providing that all other requirements of this Specification are met.

Table 701.03 – Proportions of Constituents of Mixture

701.04 PHYSICAL REQUIREMENTS

701.04.1 Softening Point

The softening point measured by the Ring and Ball method (ASTM D 36) shall be 102.5°C ± 9.5°C.

701.04.2 Color, Luminance, and Heat Stability

Color, Luminance and Heat Stability, shall be in accordance with AASHTO M 249, Clause 4.3.1.

701.04.3 Flowability and Extended Heating Flowability

Flowability shall be in accordance with AASHTO M 249, Clauses 4.3.6 and 4.3.8.

701.04.4 Flash Point

The material shall have an open flash point exceeding 230^{o}C.

701.04.5 Skid Resistance (BS 3262-3 Appendix G)

When tested in accordance with Appendix G of BS 3262-3 the skid resistance of a laboratory prepared sample of thermoplastic shall not be less than 45.

701.05 GENERAL CHARACTERISTICS

The compound shall not deteriorate because of the oil content of pavement materials or from oil droppings from traffic. In the plastic state, materials shall not give off fumes which are toxic or otherwise injurious to persons or property. The material shall not break down or deteriorate if held at the plastic temperature for a period of four hours, or by reason of four reheatings to the plastic temperature. The temperature versus viscosity characteristics of the plastic material shall remain constant through up to four reheatings, and shall be the same from batch to batch. To ensure the best possible adhesion, the material as specified, shall be installed in a melted state at a minimum temperature of 211^{o}C ± 7^{o}C, and the material shall not deteriorate if kept at this temperature for up to four hours.

701.06 SUITABILITY OF APPLICATION

The thermoplastic material shall be a product especially compounded for traffic markings. The markings shall not smear or spread under normal traffic conditions at pavement temperature below 80^{o}C. The markings shall have a uniform cross section. Pigment shall be evenly dispersed throughout its thickness. The stripes shall maintain their original dimensions and placement.

The exposed surfaces shall be free from tack and shall not be slippery when wet. Cold ductility of the material shall be in accordance with AASHTO M 249, Clause 4.3.3.

701.07 DRYING TIME

The material when applied at 211^{o}C ± 7^{o}C with its complement of glass beads, to a bituminous or concrete pavement surface under normal field conditions and thickness of 3.2 to 4.8mm, shall set sufficiently to bear traffic in not more than two minutes when the air temperature is 10^{o}C ± 2^{o}C and not more than 10 minutes when the air temperature is 32^{o}C ± 2^{o}C. After application and proper drying, the material shall show no appreciable

deformation or discoloration under local traffic conditions, and in a road temperature ranging between $0^{o}C$ and $80^{o}C$.

701.08 APPLICATION

a. The material shall be applied to the pavement by extrusion or by the spray method.

b. The material, when formed into traffic stripes, must be readily renewable by placing a thin overlay of new material directly over an old line of compatible material. Such new material shall bond itself to the line in such a manner that no splitting or separation takes place.

c. The thickness of the thermoplastic materials shall not be less than 1.5 mm except where applied to plant mix seal in which case the thickness shall not be less than 2.5 mm.

d. The materials shall be applied at the rate recommended by the manufacturer within plus or minus ten percent as determined by quantitative measurements made of the area of line applied per unit volume of material. The yield of the thermoplastic material will change according to application methods, thickness and road coarseness.

e. To ensure optimum adhesion, the thermoplastic material shall be installed in a melted state at a temperature of $211^{o}C \pm 7^{o}C$.

f. Glass beads shall be automatically applied under pressure to the surface of the material at a uniform rate of 400 to 500 g/m2. These glass beads shall be sprayed onto the thermoplastic at the time of application.

g. When recommended by the manufacturer, a binder-sealer material shall be applied to the old surface or marking prior to the actual thermoplastic installation. When sprayed, the binder-sealer material will form a continuous film over the existing surface which shall dry rapidly and strongly bond to the pavement surface.

h. No markings shall be applied when moisture or foreign matter is present on the surface or when wind conditions are such as to cause dust to be deposited on the areas or to prevent satisfactory application of the markings.

i. Markings shall be of the length width, rate and placement specified.

701.09 SAMPLES

The Contractor shall furnish to the Engineer 2kg samples each of melted and unmelted thermoplastic material and one liter of any primer together with the manufacturer's specification, for approval prior to commencement of work.

All the samples shall be properly identified with the manufacturer's code number, which shall be different for each type and color submitted. The manufacturer's name, address, type of material and code number for each sample shall be submitted with the sample.

701.10 PACKAGING

a. The materials shall be delivered in containers which do not contaminate the contents, and shall protect the contents from contamination.
b. Each container shall hold not less than 25 kg or more than 50 kg of material.

c. Each container shall be clearly and indelibly marked with the following information :

   i. The name, trademark or other means of identification of the manufacturer and address of the manufacturing plant.
   ii. Batch number.
   iii. Date of manufacture.
   iv. White or yellow.
   v. Chemical type of blinder.

vi Maximum safe heating temperature.
vii. Applicable Health and Safety information for handling, use, and disposal.

701.11 WARRANTY

The marking material furnished and installed under this Specification shall be warranted by the manufacturer against failure due to defective materials for a period of one year from the date of installation. The Contractor shall provide the manufacturer's proposed warranty for the Engineer's approval prior to ordering the marking material and shall provide the completed warranty after installation of the marking material.

701.12 REFLECTORISED TRAFFIC PAINT

701.12.1 General

An approved ready – mixed white and yellow spray type pavement marking material referred to as reflectorised traffic paint shall be applied to the pavement by means of approved pavement marking equipment. The use of this type of pavement marking and the rate of application shall be as indicated on the Drawings or in the Specifications or as directed by the Engineer.

701.12.2 Samples

The Contractor shall furnish to the Engineer a five liter sample of the paint and the manufacturer's specifications for approval prior to commencement of work.

Paint shall be fresh and furnished to the proper density and consistency for application without thinning.

701.12.3 Material Requirements

Paint to be utilised for pavement marking and striping shall be formulated for application on bituminous and portland cement concrete paving. The paint material shall have the capability of application at ambient temperatures as low as 5^{o}C. The paint shall meet the following requirements:

A. <u>General Requirements</u>

i. The paint shall provide optimum adhesion for glass spheres when both binder and glass spheres are applied in the recommended quantities. The binder should be applied at a wet film thickness of 15 mil, and the glass spheres shall be applied at the rate of 0.700 kilograms per liter of paint.

ii. The glass spheres shall be introduced into the binder immediately after the line has been applied. When the binder is heated to 55^{o}C the spheres should be applied through a pressurised glass gun set 25 mm to 100 mm behind the paint spray gun.

B. <u>Detailed Requirements</u>

i. Formulation and Manufacture

The pigmented binder shall be formulated and manufactured from first grade raw materials and shall be free from defects and imperfections that might adversely affect the serviceability of the finished product. The materials shall show no settling or jelling upon storage in the sealed shipping containers that will affect the performance of the product. The pigmented binder shall be furnished ready to use, no additional thinner shall be required.

ii. Viscosity

The consistency of the pigmented binder shall be not less than 72 Krebs units at 25^{o}C or more than 82 Krebs at 25^{o}C. It shall show excellent spraying characteristics both heated and unheated.

iii. Flexibility

The pigmented binder shall not show cracking or flaking when subjected to the flexibility test of TT-P-85 with the exception that the panels used shall be 0.180 to 0.284 mm thickness tin plate approximately 130 mm by 180 mm. The tin plates shall be lightly buffed with steel wool and shall be thoroughly solvent cleaned before they are used for the test.

iv. Directional Reflectance

The daylight directional reflectance of the pigmented binder (without glass spheres) shall be not less than 84% for the white and not less than 50% for the yellow relative to magnesium oxide when tested in accordance with Federal Test Method Standard 141 Method 6121. The yellow binder, after drying, shall be a visual match of color No. 33538 of Federal Standard 595.

v. Dry Opacity

The pigmented binders shall have a minimum contrast ratio of 0.96 for both white and yellow when applied at a wet film thickness of 0.13 mm and tested according to Federal Test Method Standard No. 141, Method 4121.

vi. Bleeding Test

Glass panels 100 mm square shall be coated with a film of fast curing asphaltic cutback. This material shall conform to ASTM D-2028 except that it shall be treated. The bituminous film shall be applied with a doctor blade capable of producing a film thickness of at least 0.25 mm on the glass panel. After curing 24 hours at 25°C, the panels shall then be baked for 5 hours at 65°C. The baked films shall then be aged in the laboratory for 72 hours prior to application of the paint. The pigmented binder shall be applied on the bituminous coated panel by means of a doctor blade capable of producing a film of 0.38 + 0.03 mm wet. After 24 hours air curing the painted panels prepared as described above shall be examined and compared with the reference standards as described in ASTM D-868 for a numerical rating. A numerical rating of 4 or less shall constitute a failure.

vii. Water Resistance

The paint prepared on panels as prescribed in TT-P-85 shall be placed in cold water at room temperature for 48 hours. The condition of the panels shall be noted after having been removed from the water at the end of two hours. There shall be no blistering, softening, deterioration, or applicable loss of adhesion.

viii. Skinning

The pigmented binder shall show no skinning either on the underside of the cover or on the surface of the liquid after 48 hours when tested in accordance with Federal Standards 141a, Method 3021.

ix. Settling

The pigmented binder in full pint triple sealed friction top unlined tin cans shall show no dense or hard settling when stored free of vibration at 50°C air temperature for 5 days. At the end of that period, the pigmented binder shall be cooled to room temperature for four hours before making the examination. The degree of settling shall have a rating of 6 or better when evaluated in accordance with ASTM D-869.

In making the test, the filled (filled to the bottom of the lip) triple sealed friction top unlined tin cans shall be placed in an inverted position for one hour to insure a complete seal between the cover and the body of the can. At the end of one hour the filled can shall be placed in an upright position for at least one hour before placing it in an air temperature of 50°C. The cans shall be placed in a single tier.

x. Drying Time

The pigmented binders, white, yellow and black when applied at a wet film thickness of 0.38 mm with a top dressing of 0.719 kilograms per liter of glass spheres shall dry to a no-tracking condition in accordance with the following table:

Paint temperature at the Spray Orifice	Maximum Allowable Drying Time
Ambient	6 minutes
37.80oC	5 minutes
49oC	4 minutes
54oC	3 minutes

These drying times shall not be exceeded when the binder is applied to a dry pavement with a surface temperature of 10°C to 60°C and the relative humidity is less than 80%.

The no-tracking condition shall be determined by passing over the applied line in a simulated passing manoeuvre with a passenger car. There shall be no visual deposition of the paint to the pavement surface when viewed from a distance of 15 meters.

xi. Abrasion Resistance

The pigmented binder shall satisfactorily pass the following abrasion resistance test:

Four (4) plate samples for each lot shall be prepared for testing on the Taber Abraser. The paint shall be sprayed on the plates or applied by other suitable means so as to ensure a nominal 0.38 mm wet film thickness on each plate. After a room temperature cure of two hours the paint abrasion panels shall then be baked at 105°C for 18 hours. The plates shall then be cleaned, dressed, weighed and abraded for 1000 cycles on the Taber Abraser. After abrading, the samples shall be cleaned with a soft brush, and weighed again. The corresponding average weight loss for the four plates shall not exceed 50 milligrams per plate. The Taber Abraser shall be operated with five hundred gram weights and CS 10 wheels on the machine.

xii. Weight Per Liter

The pigmented binder shall weigh not less than 1.378 kilograms per liter at 25°C.

xiii. Pigment Content

The pigmented binder shall conform to the following:

	% Minimum	% Maximum
Pigment	52.0	58.0
Total Vehicle	42.0	48.0

xiv. Vehicle

The vehicle shall contain not less than 37.0% non-volatile material by weight.

xv. Binder

The binder shall not require special solvents for clean-up, it shall be compatible with Toluol and Xylol.

701.13 METHOD OF EXECUTION OF THE WORKS

701.13.1 Layout for Pavement Marking

The Contractor shall lay out the work in accordance with Drawings furnished or as directed by the Engineer. The layout shall include all necessary operations to place the pavement markings. Unless otherwise specified, the Contractor shall establish control points, satisfactory to the Engineer, spaced at intervals that will ensure accurate location of strips.

701.13.2 Tolerances for Pavement Marking

Longitudinal lines shall be reasonably straight and the line shall not deviate more than 50 mm in 100 meters. STOP, crosswalk, and parking space lines shall not deviate from the dimensions shown on the Drawings more than 2%. Pavement markings outside these tolerances shall be removed and re-executed at the Contractor's expense. Removal shall be by grinding, sandblasting or other method approved by the Engineer.

701.13.3 Cleaning of Pavement for Pavement Marking

The surface shall be thoroughly cleaned of all dirt, grease, oil moisture and any other material which would affect the bond. This may be done by mechanical broom or other methods approved by the Engineer.

701.13.4 Protection of Pavement Markings

701.13.4.1 General

The Contractor shall ensure that Pavement Markings are protected from marring after application. Any markings that are marred shall be removed in accordance with Clause 1802.08.2 of Section 18 (Maintenance and Protection of Traffic) of these Specifications and replaced by the Contractor at his own expense.

701.13.4.2 Warning Flags

The application machine and the follow up support vehicle shall each be equipped, as a minimum, with four red warning flags and two 360^{o} revolving or stroboscopic yellow beacons. The rear of the vehicles shall also be equipped with a sign indicating to which side of the vehicle traffic should pass. The sign shall be as shown in 'Kuwait Manual on Traffic Control Devices'. For night working, the sign shall be illuminated by external means or, alternatively, a flashing arrow board, as specified in Section 18 (Maintenance and Protection of Traffic) of these Specifications, may be used on the rear of the vehicles.

701.13.4.3 Temporary Signage

A. <u>General</u>

These guide signs shall be used to guide traffic around the work area, and shall be installed as specified in Clause 701.15.3 of these Specifications, in accordance with latest edition of the State of Kuwait 'Kuwait Manual on Traffic Control Devices' and as specified herein.

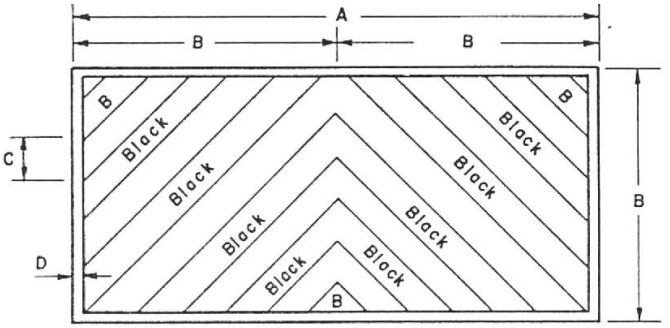
B. <u>Striped Panel Sign</u>

i. Size

The size and details for this sign shall be as shown in Figure 701.13.4.3b.

ii. Use

The Striped Panel Sign shall be used beneath the temporary arrow sign on the rear of the applicator vehicle and back-up vehicle. It may be hinged in order to cover the Temporary Arrow Sign while in transit.



COLOUR: BORDER AND STRIPES BLACK (NON REFLECTORIZED
BACKGROUND – YELLOW OR ORANGE (REFLECTORIZED)

SIGN SIZE ----	DIMENSIONS mm			
	A	B	C	D
1800 X 900	1800	900	150	30
2400 X 1200	2400	1200	200	30

Fig. 701.13.04.3b

701.14 DETAILS OF PAVEMENT MARKING WORKS

701.14.1 Description of Works

This work shall consist of furnishing all labour, materials and equipment, and applying complete in-place reflectorised white and yellow traffic paint; white and yellow hot spray-plastic; or white cold (pre-formed) applied thermoplastic in accordance with these Specifications, at the locations and of the dimensions shown on the Drawings, or as directed by the Engineer. The programme will be flexible and will be adjusted in accordance with the directions of the Engineer.

701.14.2 Details

Pavement markings shall include the following and will be in accordance with the Drawings and as directed by the Engineer.

a. Lines with reflectorised segments and gaps, 100 mm, 150 mm, 200 mm, 300 mm and 500 mm wide.

b. Solid reflectorised lines, 100 mm, 150 mm, 200 mm, 300 mm and 500 mm wide.

c. Reflectorised straight-ahead, left turn, right turn and combined straight-ahead and turn arrows and bifurcation arrows.

d. Reflectorised miscellaneous markings and lines.

e. Kerbstones shall be painted with alternating bands of black traffic paint and yellow reflectorised traffic paint. The length of each band and the portion of kerb to be painted will be directed by the Engineer.

Traffic paint shall comply with the requirements of Clause 701.12 of these Specifications, except that the requirements regarding glass beads and reflectiveness shall not apply to black paint.

The reflective paint shall be applied by brush strictly in accordance with the manufacturer's instructions regarding primers, thinning, weather conditions for application etc. The overall requirements are as follows:

i. When the paint is to be applied to a concrete surface, the manufacturer's instructions shall be followed regarding the use of an alkali-resisting primer.
ii. When the initial coat is thoroughly dry, a second coat containing 700 g of glass beads per litre shall be applied.
iii. While the paint is still wet, glass beads shall be applied as specified in Clause 702 of these Specifications.

Black paint shall be applied as specified above, except that the glass beads shall be omitted.

f. Transverse lines (Stop lines, crossings etc) must receive special attention in both the application and protection from marring by traffic.

701.15 MAIN MACHINERY AND EQUIPMENT UTILISED IN PAVEMENT SURFACE PREPARATION MARKING AND INSTALLATION OF TRAFFIC SIGNS

701.15.1 General

The Contractor shall submit a fully detailed description of each item of equipment which is to be used together with the appropriate manufacturer's catalogues and/or pamphlets.

The following equipment listed below shall be available for this Contract and the Contractor is to include in his unit rates for keeping the equipment well serviced and maintained in good condition throughout the Contract.

701.15.2 Rotary Power Broom (Cleaning Pavement Surface)

The Rotary Power Broom shall be specifically designed and manufactured by a company experienced in this type of equipment. It shall be mounted on a rubber tyred self-propelling unit having sufficient weight and power to operate the broom at a maximum speed of 15 km/h efficiently.

The Contractor is to make available all broom's fittings and any other additional attachments in order to complete the Works in a proper way and to the satisfaction of the Engineer.

701.15.3 Pavement Marking Machine (Hot Spray or Extruded Thermoplastic)

701.15.3.1 Applicator

a. Thermoplastic shall be applied utilising a truck mounted, self propelled applicator machine with a minimum gross vehicle weight of 14500 kg. The machine shall be constructed to provide continuous mixing and agitation of the material. Conveying parts of the equipment between the materials reservoir and the spray nozzle or extruder shall be so constructed as to prevent accumulation and clogging. All parts of the equipment which come in contact with the material shall be so constructed as to be easily accessible and exposable for cleaning and maintenance.

   The equipment shall be constructed so that all mixing and conveying parts, up to and including the nozzle or extruder, maintain the material at the plastic temperature.

b. The machine shall be capable of applying lines at 8 to 10 km/h and shall be able to attain normal highway speeds when changing sites.

c. The machine shall be equipped with dual operator controls located on both the left-side and right-side. Instrumentation will be provided on a console at each operator control position.

d. A spray-gun or extruder carriage shall be located on both sides of the machine and shall be electronically controlled to apply solid or broken lines up to 150 mm wide with an infinite range of accurate patterns.

e. The equipment shall be so constructed as to ensure continuous uniformity in the dimension of the stripe. The applicator shall provide a means for cleanly cutting off square stripe ends. The use of pans, aprons or similar appliances which the spray over-runs will not be permitted under this Specification.

f. The machine shall be equipped with a telescopic guide system which can be adjusted lengthwise and laterally as required.

g. The applicator shall be capable of holding a minimum of 750 kg of molten material.

h. Glass beads applied to the surface of the completed stripe shall be applied by a pressurised automatic bead dispenser attached to the machine in such a manner that the beads are dispensed almost instantaneously upon the installed line. The glass bead dispenser shall be equipped with an automatic cut-off control synchronised with the cut-off of the thermoplastic material.

i. The application machine shall be equipped with four red warning flags mounted on the four corners of the vehicle, two 360^{o} rotating or stroboscopic yellow beacons, and either a Temporary Arrow Sign and Striped Panel Sign or a Flashing Arrow Board described in Clause 701.13.4.3 of these Specifications and Section 18 (Maintenance and Protection of Traffic) of these Specifications.

701.15.3.2 Support Vehicle

a. A truck mounted support vehicle designed to support the thermoplastic applicator will be provided for an adequate supply of prepared material. It will also be utilised as a follow-up vehicle whenever material is being applied.

b. The support vehicle shall be equipped with two preheater boilers for melting and heating the thermoplastic material. Minimum capacity of each boiler shall be 380 liters. The boilers must be equipped with an automatic control device so that the heating can be done by controlled heat transfer liquid or by direct flame. The boilers shall be equipped with paddles to ensure proper agitation.

c. The support vehicle shall be equipped with four red warning flags mounted on the four corners of the vehicle, two 360^{o} rotating or stroboscopic yellow beacons, and either a Temporary Arrow Sign and Striped Panel Sign or Flashing Arrow Board as described in Clause 701.13.4.3 of these Specifications and Section 18 (Maintenance and Protection of Traffic) of these Specifications.

701.15.4 Small Pavement Marking Machine (Traffic Paint)

The Small Pavement Marking Machine shall be specifically designed for pavement marking and manufactured by a Company experienced in this type of equipment. It shall be either of the self-propelling type or suitable for easy manual operation to enable the painting of lateral pavement markings. The machine shall be equipped with either a detachable spray gun or fitted with a separate spray gun for the purpose of painting arrows and/or messages.

701.15.5 Traffic Cones

Traffic cones shall meet the requirements of Clause 1801.02.4 of Section 18 (Maintenance and Protection of Traffic) of these Specifications.

701.15.6 Pavement Marking Machine for the Application of Traffic Paint

The pavement marking machine shall be specifically designed for pavement marking and manufactured by a Company experienced in this type of equipment. It shall be suitably mounted on a self-propelling vehicle enabling the machine to proceed at a minimum speed of eight kilometers per hour during painting operations. The machine shall be equipped with an automatic skip device to enable continuous forward progress whilst painting the centerlines or lane lines as defined above, in addition to continuous marking. The machine shall also be equipped with an automatic pneumatic glass bead dispenser. The machine shall be capable of painting edge lines in addition to centerlines and lane lines.

701.16 MEASUREMENT AND PAYMENT FOR ROAD MARKING

701.16.1 Basis of Measurement and Payment

701.16.1.1 General

Payment shall be on the basis of the units of measurement as stated below and/or in the Bills of Quantities. Separate items shall be measured for thermoplastic and reflectorised traffic paint markings. The unit rates inserted by the Contractor shall be deemed to include for, but not limited to, materials, equipment, labour, workmanship, protection from marring and other related costs, overhead costs and profit, and all things necessary to complete the works in accordance with these Specifications, Drawings and as directed by the Engineer.

701.16.1.2 Broken and Solid Lines

Separate measurement shall be made for each width and color of line required. No differentiation shall be made between broken and solid lines. Lines shall be measured as the computed length in meter run of painted segments only. Payment shall be at the rates inserted in the Bills of Quantities which rates shall allow for the provision of all materials, including glass beads, labour and equipment.

701.16.1.3 Painted Kerbstones

The method of measurement shall be by meter run and payment shall be at the rates inserted in the Bills of Quantities.

701.16.1.4 Traffic Arrows

The method of measurement shall be by number for the completed arrows or symbols and payment shall be at the rates inserted in the Bills of Quantities.

701.16.1.5 Chevrons

Measurement of entry or exit ramp chevrons shall be by meter square of painted area only. Payment shall be at the rate inserted in the Bills of Quantities.

701.16.1.6 Pedestrian Crossings

Measurement of pedestrian crossings shall be by the meter square of painted area only. Payment shall be made at the rate inserted in the Bills of Quantities.

701.16.1.7 Pavement Word Markings

Measurement of pavement word markings shall be by meter square of painted area only. Payment shall be at the rate inserted in the Bills of Quantities.

701.16.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
701.1	Thermoplastic Broken and Solid Lines (width, color)	m
701.2	Reflectorised Broken and Solid Lines (width, color)	m
701.3	Painted Kerbstones	m
701.4	Traffic Arrows or symbols	nr
701.5	Chevrons	sq.m
701.6	Pedestrian Crossings	sq.m
701.7	Pavement Word Markings	sq.m

702 - GLASS BEADS

702.01 GENERAL

Glass beads for use with pavement markings for the production of a reflective surface creating night visibility of the thermoplastic and reflectorised traffic paint markings without altering day visibility of the markings shall be of a composition designed to be highly resistant to wear from traffic and to the effects of weathering.

The glass beads shall be in accordance with AASHTO M 247, Type I beads. When tested in accordance with ASTM D 1155 and D 1214, glass beads for reflectorising shall meet the requirements of AASHTO M 247 for roundness, gradation, and crushing, respectively.

702.02 GRADING OF GLASS BEADS

702.02.1 Sieve Analysis - BS

The grading of glass beads for use with thermoplastic pavement marking shall conform to BS 6088 and the following tables:

Class A – Beads incorporated in the mix.

Sieve Standard	% Passing by Mass
1.18 mm (No. 16)	97 - 100
850 um (No. 20)	90 - 100
425 um (No. 40)	0 - 10

Class B – Beads to be sprayed on the surface

Sieve Standard	% Passing by Mass
850 um (No. 20)	100
600 um (No. 30)	75 - 95
300 um (No. 50)	15 - 35
180 um (No. 80)	0 - 5

702.02.2 Sieve Analysis

The grading of glass beads for use with pavement marking paint, shall comply with that specified in AASHTO M247 Type I.

Sieve Standard	% Passing by Mass
850 um (No. 20)	100
600 um (No. 30)	75 - 95
300 um (No. 50)	15 - 35
150 um (No. 100)	0 - 5

702.03 PHYSICAL REQUIREMENTS

702.03.1 Crushing Resistance

The crushing resistance of the beads will be determined in accordance with AASHTO M247. An 81 kg dead weight for 20 to 30 mesh beads should be the average resistance of the beads tested.

702.03.2 Roundness

The beads shall contain not less than 75% spherical particles overall, and not less than 70% spherical particles on any sieve when tested in accordance with ASTM D1155. The quantity of sharp angular particles shall not exceed one per cent; particles showing milkiness, scoring or scratching shall not exceed two per cent; and foreign matter shall not exceed one percent.

702.03.3 Index of Refraction

The beads when tested by the liquid immersion method at 250^{o}C shall show an index of refraction within the range of 1.50 to 1.65. The beads shall be crystal in color and free from all film. They shall be corrected to prevent their imparting any noticeable daytime hue to the paint film.

702.03.4 Chemical Resistance

The beads shall withstand immersion in water and acids without undergoing noticeable corrosion or etching and shall not be darkened or otherwise noticeably decomposed by sulphides. The test for chemical resistance shall consist of one hour immersion in water and in solutions of corrosive agents followed by microscopic inspection.

A 3 g to 5 g portion of the sample shall be placed in each of the three pyrex glass beakers or porcelain dishes, one sample shall be covered with distilled water, one with a 3 N solution of sulphuric acid and the other with a 50% solution of sodium sulphide. After one hour of immersion the beads of each sample shall be examined microscopically for evidence of darkening and frosting.

702.03.5 Flow Properties

The beads shall pass the following moisture resistance test:

Place a 300 g portion of the air-dry sample in a 250 millilitre Erlenmeyer flask and add 5 drops of water from a pipette calibrated to produce 20 drops per millilitre (plus or minus one drop); stopper the flask immediately and shake the flask and its contents vigorously for at least one minute. Remove the stopper and connect the flask mouth to mouth to another air-dry flask of the same size in hour-glass fashion by means of stoppers joined by a short glass tube having an inside diameter of 6.35 mm; invert the assembly and observe the flow qualities of the beads. The beads shall then flow continuously into the lower flask until the upper flask is emptied. The flask may be gently tapped to initially start the flow of beads, after which the beads shall flow continuously without further agitation. If, after three trials, the beads fail to flow continuously, the sample shall be reported as failing moisture resistance test. A small quantity of beads sticking to the flask sides shall not be cause for rejection.

702.04 PACKAGING

Glass beads shall be shipped in bags or drums that are strong enough to permit normal handling during the shipment and transportation on the job without loss of beads and shall be sufficiently water resistant so that the beads will not become wet or caked in transit.

702.05 SAMPLES

The Contractor shall furnish to the Engineer 5 kg of the beads and the manufacturer’s specification for approval prior to commencement of work.

702.06 APPLICATION OF GLASS BEADS

Where beads are included in and applied to pavement markings, the beads shall be applied as specified in Clause 701.

Where reflectorised paint is applied by brush to concrete kerbs or barriers, beads shall be included in the second coat of paint only, at the rate of 700 g per liter of paint. Glass beads shall be also scattered uniformly onto the wet paint a rate of 200 g/m^2 in a manner agreed with the Engineer.

702.07 MEASUREMENT AND PAYMENT FOR GLASS BEADS

702.07.1 Basis of Measurement and Payment

No separate measurement and payment shall be made for glass beads which will be deemed to be included in the Bills of Quantities with the relevant items to which it is applied.

703 - PAVEMENT MARKERS

703.01 GENERAL

All types of pavement markers shall conform to the dimensions and shapes shown on the Drawings and shall be installed at the locations indicated on the Drawings or where designated by the Engineer.

703.02 SAMPLES

The Contractor shall submit samples of all required materials for the approval of the Engineer before manufacture.

703.03 REQUIREMENTS FOR NON-REFLECTIVE MARKERS (TYPE n)

703.03.1 General

Non-reflective pavement markers Type n shall have a base of either ceramic or plastic and shall be to the dimensions shown on the Drawings. The base of the marker shall not deviate from a flat plane by more than 1.5 mm. The top surface of the marker shall be convex and the radius of curvature shall be between 90 mm and 150 mm, except that the radius of the one centimeter nearest the edge may be less. Any changes in curvature shall be gradual. The bottom surface of the marker shall be of a roughness comparable to at least that of a fine grade of sandpaper. The bottom surface of the marker shall not be grooved such that air will be trapped in the grooves when it is pressed into the epoxy adhesive.

703.03.2 Ceramic Base

Ceramic markers shall consist of a heat-fired, white vitreous, ceramic base and a heat fired, opaque, glazed surface to produce the properties required in these Specifications. The glazed surface shall not be present on the bottom of the marker which will be cemented to the road surface. The markers shall be thoroughly and evenly matured and free from defects which affect appearance or serviceability.

The glazed surface shall have a mean thickness not less than 0.127 mm when measured not closer than 6 mm from the edge of the button to the nearest 0.0254 mm by a calibrated scale microscope.

The water absorption of the ceramic button shall not exceed 2.0 percent of the original dry weight when tested in accordance with ASTM C373.

The glazed surface of the button shall not craze, spall, or peel when subjected to one cycle of the Autoclave test at 17.58 kg/cm^2 when tested in accordance with ASTM C424.

A random sample of 5 buttons shall be subjected to the compressive load test. The average compressive strength of the 5 buttons shall not be less than 680 kg and no individual button shall have a compressive strength less than 544 kg. The button shall be centered, base down, over the open end of a vertically positioned hollow metal cylinder. The cylinder shall be 25.4 mm high, with an internal diameter of 76.2 mm and a wall thickness of 6.4 mm. A load necessary to break the button shall be applied at a speed of 2.5 mm per minute to the top of the button through a 25.4 mm diameter solid metal cylinder centered on the top of the button. In the event the bottom of the marker is dimpled a 2 mm layer of wood shall be inserted between the base of the marker and the

hollow cylinder. Should any of the samples tested for strength fail to comply with this Specification, 10 additional samples will be tested. The failure of any one of the additional samples shall be cause for rejection of the entire lot or shipment represented by the samples.

The color of the buttons shall be as designated on the Drawings or in these Specifications, shall be uniform and shall be determined by visual comparison with calibrated standards having C.I.E. Chromaticity Coordinate limits falling within a rectangle having the following corner points :

	1 X	**Y**	**2 X**	**Y**	**3 X**	**Y**	4 **X**	**Y**	**Brightness (% Mg0)**
White	0.290	0.316	0.310	0.296	0.330	0.320	0.310	0.344	80 min.
Yellowness Index : White Markers Glazed Surface Body of Marker									 0.07 max. 0.12 max.

Table 703.03.2 – Chromaticity Coordinate Limits

703.03.3 Plastic Base

The markers shall consist of an acrylic plastic shell filled with a tightly adherent potting compound. The markers shall be to the dimensions shown on the Drawings. The outer surface of the marker shall be smooth except for purposes of identification, and all edges exposed to traffic must be rounded. The base of the marker shall not deviate from a flat plane by more than 1.5 mm. The top surface of the marker shall be convex and the radius of curvature shall be between 90 mm and 150 mm, except that the radius of the 10 millimeters nearest the edge may be less. Any changes in curvature shall be gradual. The bottom surface of the marker shall be of a roughness comparable to at least that of a fine grade of sandpaper. The bottom surface of the marker shall not be grooved such that air will be trapped in the grooves when it is pressed into the epoxy adhesive.

The body of the marker shall be white.

The shell shall be moulded of methyl methacrylate or acrylonitrile butadiene styrene (ABS).

Filler shall be a potting compound selected for strength, resilience and adhesion adequate to pass physical requirements as outlined herein.

The base of the marker shall be substantially free from gloss or substance that may reduce its bond to the adhesive. This shall be done by embedding sand or inert granules on the surface of the potting compound prior to its curing.

A random sample of 5 buttons shall be subjected to the compressive load test. Each button shall be centered, base down, over the open end of a vertically positioned hollow metal cylinder. The cylinder shall be 25.4 mm high, with an internal diameter of 76.2 mm and a wall thickness of 6.4 mm. Load shall be applied at a maximum rate of 2.5 mm per minute to the top of the button through a 25.4 mm diameter solid metal cylinder centered on the top of the button. In the event the bottom of the marker is dimpled a 2 mm layer of wood shall be inserted between the base of the marker and the hollow cylinder. Failure shall constitute either a breakage or significant deformation of the marker at any load less than 907 kg. Should any of the samples tested fail to comply with this Specification, 10 additional samples will be tested. The failure of any one of the additional samples shall be cause for rejection of the entire lot or shipment represented by the samples.

Brightness will be measured with equipment conforming to ASTM E1347 using a Brightness Standard of 75%. The minimum weight of the marker shall be 125 grams.

703.04 REQUIREMENTS FOR REFLECTIVE MARKERS

703.04.1 Types w/r, w/w, a, g, and r

Type w/r, w/w, a, g and r markers shall consist of an acrylic plastic shell filled with a tightly adherent potting compound. The shell shall contain reflective faces, as shown on the Drawings, to reflect incident light. The markers shall be in the shape of a shallow frustum of a pyramid.

The outer surface shall be smooth and all corners and edges exposed to traffic must be rounded. The dimensions of the markers shall be as shown on the Drawings. The base of the marker shall not deviate from a flat plane by

more than 1.5 mm. The slope of the reflective face or faces shall be between 25 and 32 degrees from the horizontal. Each reflective surface shall have a minimum area of 2100 mm^2.

The bottom surface of the marker shall be of a roughness comparable to at least that of a fine grade of sandpaper. The bottom surface of the marker shall not be grooved such that air will be trapped in the grooves when it is pressed into the epoxy adhesive.

Type w/r markers shall have reflective faces on two opposing sides, one of which reflects white light and one of which reflects red light. The body other than the reflective faces shall be white, silver white, light grey or the color of the reflective face for the respective side.

Type w/w markers shall be as type w/r except that both reflective faces shall reflect white light.

Type a markers shall have a single reflective face which reflects amber light. The body other than the reflective face shall be white, yellow, silver white, light grey or the color of the reflective face.

Type g markers shall be as Type a except that the reflective face shall reflect green light. The body other than the reflective face shall be either white, silver white, light grey or the color of the reflective face.

Type r markers shall be as Type a except that the reflective face shall reflect red light. The body other than the reflective face shall be either white, silver white, light grey or the color of the reflective face.

The shell shall be moulded of methyl methacrylate or acrylonitrile butadiene styrene (ABS).

Filler shall be a potting compound selected for strength, resilience, and adhesion adequate to pass physical requirements as outlined herein.

The outer surface of the shell shall be smooth except for purposes of identification and shall contain methyl methacrylate reflective faces in the color specified.

The base of the marker shall be substantially free from gloss of substances that may reduce its bond to adhesive. This shall be done by embedding sand or inert granules on the surface of the potting compound prior to its curing.

Horizontal entrance angle shall mean the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of the marker.

Observation angle shall mean the angle at the reflector between observer's line of sight and direction of the light incident on the reflector.

Specified Intensity (SI) shall mean candelas of the returned light at the chosen observation and entrance angles for each lux per square meter of illumination at the reflector on a plate perpendicular to the incident light.

The specific intensity of each crystal reflecting surface at 0.2^o observation angle shall be not less than the following when the incident light is parallel to the base of the marker.

Hor. Ent. Angle	**Specific Intensity**
0^o	3.0
20^o	1.2

Red, green and amber reflectors shall be not less than 25% of the above values.

A random sample of 5 markers of each type will be tested. The markers to be tested shall be located with the centre of the reflecting face at a distance of 1524 mm from a uniformly bright light source having an effective diameter of 5.1 mm

The photocell width shall be 1.27 mm. It shall be shielded to eliminate stray light. The distance from light source centre to the photocell centre shall be 5.33 mm. If a test distance of other than 1524 mm is used, the source and receiver shall be modified in the proportion as the test distance.

Markers shall support a load of 907 kg as applied in the following manner:

A marker shall be centered over the open end of a vertically positioned hollow metal cylinder. The cylinder shall be 25.4 mm high, with an internal diameter of 76.2 mm and wall thickness of 6.4 mm. Load shall be applied at a maximum rate of 2.5 mm per minute to the top of the marker through a 25.4 mm diameter metal plug centered on the top of the marker. In the event the bottom of the marker is dimpled a 2 mm layer of wood shall be inserted between the base of the marker and the hollow cylinder.

Failure shall constitute either a breakage or significant deformation of the marker at any load of less than 907 kg.

Should any of the samples tested for reflectivity and strength fail to comply with the Specifications, 10 additional samples will be tested. The failure of any one of the additional samples shall be cause for rejection of the entire lot or shipment represented by the samples.

703.04.2 Type d

Type d reflective markers shall be ceramic manufactured in accordance with the Specification given below. The markers shall be white colored having dimensions as detailed on the Drawings.

The encapsulated lens reflector shall be red in color and shall have optical and physical characteristics recommended by the manufacturer and as approved by the Engineer.

Ceramic markers shall consist of a heat-fired, white vitreous, ceramic base and a heat-fired, opaque, glazed surface to produce the properties required in these Specifications. The glazed surface shall not be present on the bottom of the marker which will be cemented to the road surface. The markers shall be thoroughly and evenly matured and free from defects which affect appearance on serviceability.

The glazed surface shall have a mean thickness not less than 0.127 mm when measured not closer than 6 mm from the edge of the button to the nearest 0.0254 mm by a calibrated scale microscope.

The water absorption of the ceramic button shall not exceed 2.0 percent of the original dry weight when tested in accordance with ASTM C373.

The glazed surface of the button shall not craze, spall, or peel when subjected to one cycle of the Autoclave test at 17.58 kg/cm2 when tested in accordance with ASTM C424.

The color shall be uniform and shall be determined by visual comparison with calibrated standards having CIE Chromasticity Coordinate limits falling within a rectangle having corner points as detailed on Table 703.04.2.

	1 X Y	**2 X Y**	**3 X Y**	**4 X Y**	Brightness (% Mg0)
White	0.290 0.316	0.310 0.296	0.330 0.320	0.310 0.344	80 min.
Yellowness Index : White Markers Glazed Surface Body of Marker					 0.07 max. 0.12 max.

Table 703.04.2 – Chromaticity Coordinate Limits

703.05 EPOXY ADHESIVE

The adhesive shall be furnished as two components, each packaged separately. The components shall have the following compositions:

Package A	**Parts by Weight**
Epoxy Resin	100.00
Titanium Dioxide	7.31
Talc	37.64
Package B	**Parts by Weight**
N-Aminoethyl Piperazine	23.16
Nony phenol	52.00
Carbon Black	0.22
Talc	77.37

At the time of use the contents of packages A and B shall be thoroughly redispersed by mixing. One volume or weight of Package A shall be mixed with one volume or weight of Package B until a uniform grey color is achieved without visible streaks of white or black.

A blend of 1 part of component A and 1 part of component B shall exhibit the following properties:

i.	Gel time (100 g Batch)	5-30 minutes
ii.	Tensile strength (1.6 mm film between steel blocks cured 24 hours at 21oC) Tested at 21oC	(min) 70 kg/cm2
iii	Shore D Hardness	(Cured 24 hours at 21^{o}C)
	Tested at 21^{o}C	70-80
	Tested at 70^{o}C	(min) 30

The manufacturer shall certify that each batch of adhesive conforms to these Specifications.

The lot or batch number shall appear on the certificates, on all samples and on all lots of adhesives delivered. A 0.6 liter sample of the A and B components shall be sent to the Engineer by the Contractor not less than 10 days before using.

703.06 CONSTRUCTION REQUIREMENTS

703.06.1 General

The location of the markers shown on the Drawings is approximate and the actual location will be as directed by the Engineer.

Shipments shall be made in containers which are acceptable to common carriers and packaged in such a manner as to ensure delivery in perfect condition. Any damaged shipments shall be replaced by the Contractor at his own expense. Each package shall be clearly marked as to the name of the manufacturer, type of marker, color, quantity enclosed, lot number, and date of manufacture.

The Contractor shall furnish certificates from an independent, reputable testing laboratory acceptable to the Engineer, certifying that the markers and adhesives comply with these Specifications.

When the project is complete, the markers shall be firmly bonded to the pavement. Lines formed by the markers shall be true and the entire installation shall present a neat appearance.

703.06.2 Surface Preparation

All sand, dirt and loose extraneous material shall be swept or blown away from the marker location and the cleaned surface prepared by one of the following procedures:

a. The pavement surface shall be heated by intense radiant heat (not direct flame) for a sufficient length of time to char extraneous, organic surface contaminants but not to exceed 90 seconds.

b. The pavement surface shall be sandblasted for a sufficient length of time to remove all surface contaminants and unsound particles but not so long as to expose buried aggregate. A hot air blast shall be used to remove loose sand and dirt from the blasted areas and insure that the surface is completely dry.

703.06.3 Marker Preparation

The resin-rich, waxy or greasy surface that characterises the markers is not satisfactory as a bonding surface. A satisfactory bonding surface may be secured by: 1) sanding off the bottom of the marker, or 2) structurally bonding a layer of glass beads or sand into the bottom surface during manufacture.

When it is necessary for the adhesive to achieve the minimum bonding strength within 5 minutes, the markers shall be preheated as described below in Clause 703.07 of these Specifications.

703.06.4 Adhesive Preparation

The adhesive shall be maintained at a temperature of 15°C to 29°C before use and during application.

Catalyst shall be added to the base just before the use and mixed to a smooth, uniform blend. Unused mixed adhesive shall be discarded when catalytic action has caused stiffening and reduction of workability.

703.07 APPLICATION PROCEDURE

703.07.1 General

The mixed adhesive shall be applied to the prepared pavement area to be covered by the marker and the marker pressed into place so as to squeeze out a small bead of adhesive around the entire periphery of the marker. The required amount of adhesive per marker will normally be in the range of 20 to 40 g.

Lane markers shall be spaced and aligned as shown in the Drawings and as directed by the Engineer. A displacement of not more than 10 mm, left or right of the established guide line will be permitted. The Contractor shall remove and replace at his own expense all improperly placed markers. The markers shall be installed on dry pavement.

Unless otherwise approved by the Engineer, adhesive shall be machine mixed by a metered mixing dispenser and the adhesive provided and so used shall be clearly marked and designated by the manufacturer as “Machine Mix Standard Set” or “Machine Mix Rapid Set”.

703.07.2 Standard Adhesive Set

On highway sections that are not open to public traffic, it will not be necessary to preheat the markers provided the adhesive develops the required bond strength in tension of 124 g/cm^2 in less than 3 hours.

703.07.3 Rapid Adhesive Set

On highway sections that are open to public traffic, the Contractor shall preheat the highway surface and the markers so as to ensure the bonding of the marker in not more than 5 minutes. Bonding will be considered satisfactory when adhesive develops minimum bond strength in tension of not less than 124 g/cm^2.

Markers, whose surfaces have been prepared by sanding or structural bonding beads, may be preheated in either a fluid heating bath or a dry oven controlled between 135°C and 150°C for not less than 10 minutes before setting.

The sequence of operations shall be as rapid as possible. Adhesive shall be in place and the marker seated in not more than 30 seconds after the removal of the pavement preheat or warm air blast. The marker itself shall not have cooled more than one minute before seating.

703.08 MEASUREMENT AND PAYMENT FOR PAVEMENT MARKERS

703.08.1 Basis of Measurement and Payment

Measurement for non-reflective, reflective (regardless of color combinations) or type d pavement markers on the highway shall be by the number of each installed, complete as shown on the Drawings and as directed by the Engineer.

Payment shall be at the rates inserted in Bills of Quantities for each non-reflective, reflective or type d pavement marker and the payment thereof shall be full compensation for furnishing and installing each unit and shall be deemed to include, but not be limited to, materials, equipment, labor, protection from marring and other related costs, overhead costs and profit and all work necessary to complete the Works in accordance with these Specifications, as shown on the Drawings and the directions of the Engineer.

703.08.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
703.1	Non-reflective pavement markers (type n)	nr
703.2	Reflective pavement markers (type a, g, r, wr, ww)	nr

703.3	Reflective pavement markers (type d)	nr

704 - TRAFFIC SIGNS

704.01 GENERAL

All Guide Signs may be subject to revision during the Contract.

704.02 SAMPLES

The Contractor shall submit samples of all required materials for approval of the Engineer before manufacture.

704.03 REQUIREMENTS

704.03.1 Description

This work shall consist of furnishing and installing reflectorised sign panels, sign supports, and sign support foundations as shown on the Drawings, in accordance with these Specifications, or as directed by the Engineer and approved by Ministry of Interior (MOI) Traffic Department.

704.03.2 Definition of Signing Terms

A. Brightness

A measurement of the ratio of the quantity of incident light per unit area returned to an observer from a reflector. This measurement is expressed in units of candelas per lux per square meter.

B. Divergence Angle

The angle at the reflector between the observer's line of sight and the axis of the incident light beam.

C. Entrance Angle

The angle at the reflector between the axis of the incident light beam and the normal to the reflective surface.

D. Intensity

A measurement of the ratio of the quantity of incident light per total area returned to an observer from a reflector. This measurement is expressed in units of candelas per lux per square meter.

E. Legend

Characters, letters, numbers and symbols including the border appearing on the background on the sign face.

F. Sign Face

That part of a sign panel facing towards oncoming traffic.

G. Sign Panel

The structural part of a sign made of assembled units or sheet metal, including reflectorised material applied to the face and bearing a legend, but excluding the supporting posts or structure.

H. The posts, beams or trusses necessary to support the sign panels shall be as shown on the Drawings.

704.03.3 Materials

A. General

The materials for the construction of foundations, supports and panels shall conform to the requirements of the following Sections of the General Specifications unless otherwise specified in this Section.

Material	Section
Portland Cement Concrete	5
Reinforcing Steel	5
Structural Steel	12
Paint	12
Aluminum Panels	12

Table 704.03.03a - Material Specification Sections

B. Sheet Reflective Materials

Type I – Enclosed lens and Type II – Encapsulated lens.

i. Description

The reflective sheeting shall be of Type I – Enclosed lens consisting of spherical lens elements embedded within a transparent weatherproof film having a smooth, flat outer surface or Type II – Encapsulated lens consisting of spherical lens elements adhered to a synthetic resin and encapsulated by a flexible transparent weatherproof plastic having a smooth outer surface. The sheeting shall have a pre-coated adhesive backing protected by a removable liner and be either of two levels of reflective intensity as specified on the Drawings or in this Section of these Specifications. Type II sheeting shall be used unless otherwise shown on the Drawing or directed by the Engineer/MOI's Traffic department.

ii. Color Requirements

The chromaticity of the colors specified on the Drawings shall comply with Table 704.03.3b and Fig. 704.03.3b herein, and shall be determined in accordance with BS EN12899

When the area of the sign plate is larger than the area of the sign, the area outside the sign shall be colored grey. The color shall be "Aircraft Grey" in accordance with BS 381C, Color Number 693.

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
Red	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345
Orange	0.610	0.390	0.535	0.375	0.506	0.404	0.570	0.429
Yellow	0.545	0.454	0.487	0.423	0.427	0.483	0.465	0.534
Green	0.030	0.380	0.166	0.346	0.286	0.428	0.201	0.776
Blue	0.078	0.171	0.198	0.252	0.240	0.210	0.137	0.038
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375

Table 704.03.3b Color Specifications for Sheet Reflective Materials

iii. Luminance and Reflective Intensity

1. The Luminance factor of the sign face material shall comply with Table 704.03.3c when measured as described in BS EN12899.

Color	Retro-Reflective		Ordinary Colors	
Red	0.03 min.	0.11 max.	0.07 min.	0.13 max.
Orange	0.17 min.	0.30 max.	0.20 min.	0.30 max.
Yellow	0.16 min.	0.40 max.	0.50 min.	0.60 max.
Green	0.01 min.	0.07 max.	0.04 min.	0.07 max.
Blue	0.01 min.	0.10 max.	0.05 min.	0.10 max.
White	0.25 min.		0.75 min.	
Grey	Not applicable		0.15 min.	0.25 max.
Black	Not applicable			0.05 max.

Table 704.03.3c Luminance Factors for Sign Face Material

2. The reflective sheeting shall have minimum reflective intensity values (coefficient of retro–reflection) as shown in Table 704.03.3d or 704.03.3e expressed as candelas per lux per square meter of materials.

iv. Specular Gloss

The reflective sheeting shall have an 85 degree specular gloss of not less than 40 for Type I and not less than 50 for Type II when tested in accordance with ASTM D 523.

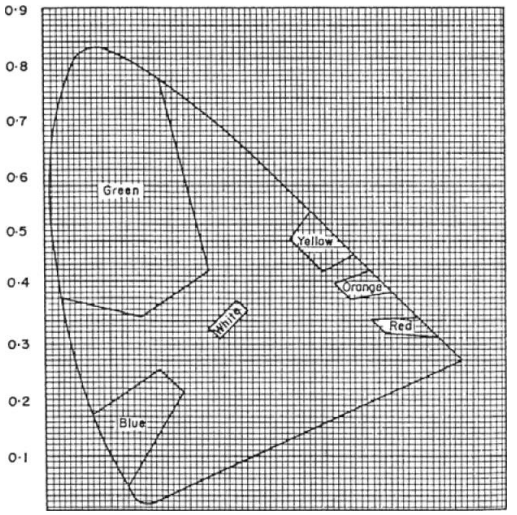


Fig. 704.03.3b

v. Processing

The sheeting shall permit cutting and color processing with compatible transparent and opaque process inks at temperatures of 15°C to 38°C and relative humidity of 20 to 80 percent. The sheeting shall be heat resistant and permit force curling without staining of applied or unapplied sheeting at temperatures as recommended by the manufacturer. Color processing for Type II material shall be restricted to sheeting with heat activated adhesive backing unless otherwise recommended by the manufacturer.

vi. Shrinkage

A 229 mm x 229 mm reflective sheeting specimen with liner shall be conditioned a minimum of 1 hour at 23°C and 50% relative humidity. The liner shall be removed and the specimen placed on a flat surface with the adhesive side up. Ten minutes after liner is removed and again after 24 hours, the specimen shall be measured to determine the amount of dimensional change. The reflective sheeting shall not shrink in any dimension more than 0.79 mm in 10 minutes nor more than 3.18 mm in 10 minutes nor more than 3.18 mm in 24 hours.

vii. Flexibility

1. Type I Enclosed Lens Materials

The sheeting, applied according to the manufacturer's recommendations to a clean, etched 0.51 mm by 50.18 mm by 203 mm aluminum panel of alloy 6061-T6 conditioned a minimum of 48 hours and tested at 23°C and 50% relative humidity shall be sufficiently flexible to show no cracking when bent around a 19.1 mm mandrel.

2. Type II - Encapsulated Lens Materials

The sheeting, with the liner removed and conditioned for 24 hours at 23°C and 50% relative humidity, shall be sufficiently flexible to show no cracking when bent, in one second's time, around a 3.2 mm mandrel with adhesive contacting the mandrel.

Note: For ease of testing, spread talcum powder on adhesive to prevent sticking to the mandrel.

viii. Adhesive

The reflective sheeting shall include a pre-coated pressure sensitive adhesive backing (Class 1) or a tack-free heat activated adhesive backing (Class 2) either of which may be applied without necessity of additional adhesive coats on either the reflective sheeting or application surface.

1. The Class 1 adhesive backing shall be a pressure sensitive adhesive of the aggressive tack type requiring no heat solvent or other preparation for adhesion to smooth clean surfaces.

2. The Class 2 adhesive backing shall be a tack-free adhesive activated by applying heat in excess of 63oC to the material as in the heat-vacuum process of sign fabrication.

Entrance Angle	Observation Angle	Minimum Coefficient of Retro-Reflection candelas/lux/m^2				
		Red	Yellow	Green	Blue	White
-5 degrees	12’	12	50	5	4	70
	20’	10	35	5	3	50
	1.0 degree	1.5	3	1	0.6	5
15 degrees	12’	10	35	3	3	55
	20’	8	20	3	2	45
	1.0 degree	1	2	1	0.3	3
40 degrees	12’	3	8	1	1	15
	20’	2.5	5	1	0.8	10
	1.0 degree	0.3	0.5	0.2	0.1	1.5

Table 704.03.3d Minimum Reflective Intensity Values for Type I Enclosed Lens Sheeting

Entrance Angle	Observation Angle	Minimum Coefficient of Retro-Reflection candelas/lux/m^2				
		Red	Yellow	Green	Blue	White
-5 degrees	12’	35	170	30	20	250
	20’	25	120	20	14	180
	1.0 degree	2	12	1	1	20
15 degrees	12’	30	120	20	15	200
	20’	20	80	15	10	150
	1.0 degree	1.5	8	1	0.7	15
40 degrees	12’	16	80	9	9	120
	20’	13	65	7	7	95
	1.0 degree	1	3	0.5	0.5	5

In no circumstances shall the coefficient of retro-reflection of any material exceed 1000 cd/lux/m^2.

Table 704.03.3e
Minimum Reflective Intensity Values for Type II Encapsulated Lens Sheeting

The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solvents without breaking, tearing or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for 4 hours at 71^oC under a pressure of 17 kPa

The adhesive backing of the reflective sheeting shall produce a bond to support a 0.79 kg weight for 5 minutes, without the bond peeling for a distance of more than 51 mm when applied to a smooth aluminum surface.

ix. Impact Resistance

The reflective sheeting material, applied according to the manufacturer’s recommendations to a cleaned, etched aluminum panel of alloy 6061-T6 0.10 mm by 102 mm by 127 mm and conditioned for 24 hours at 23^oC and 60% relative humidity, shall show no cracking when the face of the panel is subjected to an impact of a 0.9 kg

weight with a 16 mm rounded tip dropped from a 1.13 N.m. setting on a Gardner Variable Impact Tester, 1G-1120.

x. Durability

Processed and applied in accordance with recommended procedures the reflective material shall be weather resistant and, following cleaning, shall show no appreciable discoloration, cracking, blistering or dimensional change and shall not have less than 50% of the specified minimum reflective intensity values (Tables 704.03.3d and 704.03.3e) for Type I enclosed lens sheets and not less than 70% for Type II encapsulated lens sheeting when subjected to accelerated weathering for 1,000 hours or 2,200 hours, respectively, in accordance with ASTM Standard G152-06 and G153-04, Type E or EH Weatherometer.

xi. Use

The desired level of reflective intensity value Type I – Enclosed Lens or Type II – Encapsulated Lens, and the type of adhesive backing, Class 1, precoated pressure adhesive or Class 2, heat activated adhesive, shall be as shown on the Drawings or as designated by the Engineer.

C. Other Materials

All other materials for signs shall be as shown on the Drawings and as specified herein.

D. Handling and storage

All materials shall be new and shall be handled and installed in a workmanlike manner in conformance with these Specifications, the Drawings, and as directed by the Engineer. The Contractor will not be permitted to store material used for construction on the pavement or shoulder. Signs stored on or near the job site shall be under a roof or otherwise covered for protection against weather and dirt. Materials shall be stored in such a manner that they will not be on the ground or come in contact with surface run-off water.

704.03.4 Steel Sign Panels

a. The traffic sign panels shall be of steel with reflective sheeting all as specified herein and as shown on the Drawings.

b. Sign panels shall be prefabricated sheet steel blanks, a minimum of 2 mm thick continuous coat galvanised and conforming to ASTM A653M. Zinc coating shall be designation G90 and in addition all sheets are mill phosphatised to a thickness of 1.0 +0.5 g/m^2 of surface area. The finished plate for the sign panels shall be free of twist or buckle and the background shall be substantially a plane surface. The panels shall be cleaned, degreased or otherwise prepared in accordance with approved methods recommended by the sheeting manufacturer.

704.03.5 Aluminum Sign Panels

A. Extruded Aluminum Channels

Extruded aluminum channels shall be used for all Major Directional Signs and for Motorway Exit signs and shall be as shown on the Drawings.

B. Sign Blanks

The sign blanks shall be free from laminations, blister, slivers, open seams, pits from heavy rolled-in scale, ragged edges, holes, turned down corners, or other defects which may affect their appearance or use for the intended purpose. All blanks shall be as nearly uniform in thickness as is practicable and shall be commercially flat. All shearing, cutting, and punching shall be done prior to preparing the blanks for the application of reflectorising material. The sheared edges of all blanks shall be straight and free from tears and raggedness. All punched or drilled holes shall be round, free from tears, raggedness, or distortion of the metal.

C. Aluminum Sign Base Material

Aluminum sign base material, before the application of reflective sheeting, shall be prepared as follows:

i. The blank panel shall be given a preliminary cleaning by being completely submerged in a 3% solution of an inhibited alkaline cleanser at 70°C to 80°C for 3 minutes, followed by a thorough rinse with clean, running cold water. As an alternate, a grease solvent such as naptha, or trichloroehtylene may be used, provided the application is in strict accordance with the directions of the manufacturer of the cleaner.

ii. Preliminary cleaning shall be followed by etching. This shall consist of immersion for at least 3 minutes in a 6% to 8% solution of phosphoric acid at 40°C. The blank panels shall then be rinsed in a spray of cold water, followed by immersion for one minute in circulating hot water at 80°C. They shall then be dried by forced warm air or infra-red lamps.

iii. If a chemical conversion coating is used, the coating shall be light, tight, and free from all powdery residue. If total immersion is impossible because of the length of the panels, 6% to 8% phosphoric acid at 40°C may be applied to the surface by swabbing, brushing, or spraying, allowed to remain for 5 minutes, and then removed by a cold water rinse, followed by drying with warm or forced air.

iv. The metal shall not be handled except by a device or clean canvas gloves between all cleaning and etching operations and the application of reflective sheeting. There shall be no opportunity for the metal to come in contact with greases, oil, or other contamination prior to the application of reflective sheeting.

D. Aluminum Channels

When the reflective sheeting is applied to individual extruded aluminum channels, the channels shall be assembled after the background sheeting has aged for 48 hours at 24°C. The channels shall be bolted together using the panel bolt assembly shown on the Drawings and shall be on 600 mm maximum centers. Nuts on panel bolts shall be drawn tight.

E. Side-Trim Moulding

Side-trim moulding shall be installed on both vertical edges of the extruded aluminum panels after the clear finish has dried. Any damage to the clear film shall be repaired and the contact between the moulding and the reflective sheeting shall be edge sealed as recommended by the sheeting manufacturer.

704.03.6 Application of Background Sheeting

a. The background reflective sheeting shall be applied to the steel sign panels or extruded channels, which have been prepared as described above, in the manner recommended by the manufacturer. Reflective sheeting shall be applied to all sign faces by an approved vacuum or continuous roll applicator. The background reflective sheeting shall adhere over and around the sides of all panels to a minimum distance of 2 mm beyond the edges.

b. Type I or Type II sheeting with Class 1 pressure sensitive adhesive:

   Pressure sensitive sheeting shall be applied to the individual extruded channels, to assembled panels of extruded channels, and to those sheet panels that are too large for the approved vacuum applicator. Type I sheeting shall be applied by a continuous roll applicator. The process shall be in strict conformance with the recommendations of the reflective sheeting manufacturer and shall be approved by the Engineer.

c. Type I or Type II sheeting with Class 2 heat activated adhesive:

   Heat activated adhesive shall be applied to sheet panels capable of being inserted in the approved vacuum applicator. The legend, for signs which will have the legend screened onto a Type II (heat activated adhesive) reflective sheeting, shall be added to the background before the sheeting is applied to the panel.

d. When the vacuum is applied, the precoated adhesive on the back of the Type II sheeting shall be activated by a minimum temperature of 85°C and with a minimum vacuum pressure of 635 mm of mercury. This operation shall be in effect for a minimum of 5 minutes. After aging for 48 hours at 24°C the adhesive shall form a bond equal to or greater than the strength of the reflective sheeting.

e. Splicing of reflective sheeting shall not be permitted on signs or panels with dimensions up to and including 1200 mm in height or width unless the reflective sheeting specified does not come in this width, then the widest width of material available shall be used. No vertical joints shall be permitted in reflective sheeting on signs or panels of any height or width.

When sheeting joints are required, they shall be lap-jointed with the top sheet overlapping the bottom sheet by no less than 5 mm. The fabricator shall endeavour to use the least number of seams possible. Roller applicated or reverse screened sheeting may be butt-jointed with joint gap not to exceed 1.0 mm. No splice shall fall within 50 mm of the edge of the panel.

f. Sign faces comprising two or more pieces of reflective sheeting must be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance, both day and night. Non-conformance may result in non-uniform shading and an undesirable contrast between adjacent width of applied sheeting which will not be acceptable.

g. Damaged or unsatisfactory reflective sheeting due to poor workmanship or defective material will be rejected, and shall be replaced at the Contractor's own expense.

704.03.7 Sign face Layout

The legend and backgrounds to be applied to the sign panel shall comply with the following specifications, the Drawings and the relevant appendix of the Particular Specification.

A. Sign Layout, Traffic Signs

as specified herein and as shown on the Drawings. The legend shall be applied to the reflectorised sheeting in the manner recommended by the manufacturer.

B. Sign Layout, Guide Signs

The shape, size, legend and colors of all guide signs shall be as shown on the Drawings or in the Contract Documents.

The English and Arabic lettering shall consist of the letters and numbers applied to the background in the sizes and spacing shown on the Drawings or in the Contract Documents.

The sign shape, size, legend and lettering of traffic signs and guide signs shall be done according to Kuwait Traffic Manual.

704.03.8 Application of Lettering

a. The legend for the standard international signs shall be applied directly to the Type II background sheeting by the reverse silk-screen method recommended by the manufacturer and approved by the Engineer.

b. Black letters on a white or yellow background shall be screened with an opaque black stencil paste, as recommended by the manufacturer of the reflective sheeting. The signs with silver-white letters on a red, blue, brown or green background shall be applied to the sheeting using the reverse screening process on a silver-white sheet reflecting background, and using screen pastes meeting the recommendations of the manufacturer of the silver-white sheeting.

c. For all other signs, the Arabic letters shall be screened directly onto the background sheeting wherever possible. Where the sign panel and/or letter are too large for the letters to be screened directly on the background sheeting, the letters shall be screened onto a strip of reflective sheeting whose reflective surface is identical to the background sheeting. Each letter shall be adhered to the background by the method recommended by the manufacturer and approved by the Engineer.

d. English letters may be applied directly to the background sheeting by the reverse screening method if the height of the letters shown on the Drawings is 200 mm or less, and if the sign panel can be accommodated by the vacuum applicator. Letters higher than 200 mm shall be made using the cut-out method. All letters in any one line of copy shall be applied using only one method.

e. When the cut-out method is to be used for English letters, the Contractor or the sheeting manufacturer shall prepare templates for each letter and each height shown on the Drawings, and these templates shall be approved by the Engineer. The templates shall be used as guides for cutting the letters out of Type I reflective sheeting. Legend and borders shall be reflective sheeting of the color specified on the Drawings and shall be applied directly to clean, dust-free reflective sheeting background panels, and shall be applied in a manner specified for the manufacture of traffic control signs by the sheeting manufacturer.

f. Legend and/or borders shall be cut neatly at intersecting panel edges.

g. The legend and border shall have clean, clear edges, true to line, and be strictly in accordance with the plans as to design of letters and positioning on the sign.

h. Applied legend and borders shall be finished with materials and in a manner specified by the sheeting manufacturer. Finish shall be as indicated herein:

   i Type I adhesive coated sheeting legend and/or borders shall be edge sealed with "Finishing Clear" after application.

   ii. Sheeting cuts at intersecting panel edges shall be edge sealed with "Finishing clear" following application.

      1. After the message and border application, the complete sign including edges shall be finished by a clear coating approved by the sheeting manufacturer.

704.03.9 Installation of Ground Mounted Signs

a. Unless otherwise noted, the location of the signs shown on the Drawings are approximate and the exact location will be established by the Engineer/MOI's Traffic Department in the field.

b. It shall be the responsibility of the Contractor to determine the location of any underground electric cable, drainage structures, or utility lines in the vicinity before beginning his work, and he shall conduct his work so as to avoid damage to these installations. The Contractor shall contact the Engineer for assistance in locating utilities, drainage structures, and other underground facilities that have been installed during the construction of the highway. Any damage caused by the Contractor's operation shall be repaired by him, at his own expense, and to the satisfaction of the Engineer and the relevant Authority owning the facility.

c. The Contractor shall be responsible for the proper elevation, offset, and effective orientation of all signs. They shall be erected so that the face of the sign is vertical and oriented as indicated on the Drawings, or as directed by the Engineer/MOI's Traffic Department, to provide the most effective display for both day and night. All signs shall be complete and installed to the satisfaction of the Engineer and MOI's Traffic Department at the time of acceptance of the work. Sign faces shall be examined by the Engineer both during conditions of daylight and darkness.

d. When so notified by the Engineer/MOI's Traffic Department, the Contractor shall cover certain signs to facilitate and control the operation of the project and maintenance and protection of traffic. The covering shall consist of plywood or metal sheet, securely fixed so that the requisite area of the sign panel will be invisible. The Contractor shall not use any type of adhesive tape on the face of the signs. Other methods of covering may be proposed by the Contractor for the approval of the Engineer/MOI's Traffic Department.

e. The Contractor shall replace, at his own expense, any sign or sign support included in the Contract which is damaged from any cause whatsoever, including traffic damage, prior to acceptance by the Engineer/MOI's Traffic Department.

704.03.10 Foundations

A. Excavations

All excavation required for footings, columns, wings, tie beams and slabs, shall be done through whatever materials are encountered, and to the dimensions and elevation shown on the Drawings or as established by the Engineer, and in accordance with the requirements of Section 2 (Earthworks) of these Specifications. Column shafts shall be excavated by drilling.

B. Footings for Ground-Mounted Signs

The stub posts to be embedded in drilled shaft foundations shall be set carefully in the foundation holes and held vertically in place by an approved template before the concrete for the foundation is placed.

The forms and templates supporting the sign posts shall not be removed until the concrete has gained the specified 28-day working strength. Springing or raking of posts to secure proper alignment will not be permitted.

C. Foundations for Overhead Sign Support Structures

The electrical conduit (where required) and anchor bolts of the size, length and number as shown on the Drawings shall be positioned before the concrete is placed. Anchor bolt groups shall be set and maintained in position with a template during the placement of that portion of concrete into which anchor bolts are embedded. Care shall be taken to obtain the orientation of the anchor bolts and spacing of the anchor bolt groups as shown on the Drawings. Where conduit is required, it shall extend one meter beyond the foundation surface to permit electrical connections.

D. Concrete Works

All concrete works at sign foundations, including reinforcing steel, shall be in accordance with Section 5 (Concrete Works) of these Specifications. All parts of the Concrete foundations extending above the natural or finished ground line shall be given a Class 2 rubbed surface finish in accordance with Section 5 (Concrete Works) of these Specifications. The footings for ground-mounted signs shall not extend more than 100 mm above the finished grade.

No structure or post shall be erected on a concrete foundation nor shall any traffic sign be attached to a signpost embedded in concrete until the concrete has gained the specified 28-day strength.

E. Backfilling and Compaction

All backfilling and compaction shall be completed prior to the erection of any sign on the structure. Unless otherwise shown on the Drawings, backfilling shall be carried out in accordance with Clause 208.07 of Section 2 (Earthworks) of these Specifications.

Where embankment protection or surfacing is removed for placing foundations for traffic signs, it shall be replaced with like material as directed by the Engineer.

704.03.11 Sign Supports

A. Support Posts

The length of the posts for each traffic sign shown on the Drawings shall be determined by the Contractor before ordering in order to meet the existing field conditions and to conform to the sign-mounting heights shown on the Drawings. After fabrication the post and stub post shall be galvanised in accordance with ASTM A123. All fabrication shall be completed and ready for assembly before galvanising. No punching, drilling, burning, or cutting shall be permitted after galvanising. Any part of the post from which the galvanising has been damaged in fabrication, transit, or erection or when bare metal is exposed shall be repaired to the satisfaction of the Engineer by application of galvanising repair compounds, or by re-galvanising, as directed by the Engineer.

B. Break-Away Assembly

The “break-away” assembly shall be constructed by attaching the post to the stub post with high strength bolts and one flat washer on each bolt between the plates as shown on the Drawings. Shims may be used between the plates as shown on the Drawings. Shims may be used between the plates to align the posts. The bolts shall be tightened in a systematic order to the required torque shown on the Drawings. Then each bolt in turn shall be loosened and retightened to the required torque in the same order as the initial tightening. The threads shall be burred or centre punched at the juncture of bolt and nut to prevent the nut from loosening.

C. Post Installation

The size and number of posts required to support each sign panel installation shall be as shown on the Drawings.

The post or posts shall be vertical. When two posts support the same panel, they shall be erected vertical and parallel with each other with the tops of the posts at the same height.

D. Structural Beams for Ground-Mounted Signs

The size of the steel wide-flanged beams required to support each sign shall be as shown on the Drawings.

The structural steel sign support posts shall be erected in a vertical position on a previously prepared foundation, with the tops of the posts in each sign installation even, level with each other, and extending 100 mm above the top of sign panel. The faces of the supporting posts shall be flush with the sign throughout the contact areas.

Springing or raking of posts to secure proper alignment will not be permitted.

E. Support Structures for Overhead Signs

The overhead sign support structures which are to be employed to support sign panels over the highway (both those independent of other highway structures and those mounted on bridges) shall be as shown on the Drawings. The work for the sign support shown on the Drawings. The work for the sign support structure shall not include the sign panel or panels or the sign illumination which are specified elsewhere in these Specifications.

i. Span

The span of independent support structures shall be as shown on the Drawings.

ii. Shop Fabrication Drawings

Four sets of shop fabrication drawings for the steel sign support structures including support posts and walkways as applicable shall be submitted to the Engineer for approval prior to fabrication.

iii. Fabrication and Inspection

Fabrication and inspection of steel sign support structures including support posts and walkways as applicable, shall be governed by the relevant requirements of Section 12 (Metal Works) of these Specifications.

iv. Galvanising

All metal parts of support structures for overhead signs, where shown in the Contract Documents, shall be hot-dip galvanized in accordance with ASTM A 123.

F. Defective Welds

Welds deemed by the Engineer to be unsatisfactory on any structural members shall be removed by mechanical means, reannealed, rewelded and reheat treated, all to the approval of the Engineer, or new structural members having satisfactory welds shall be provided. Flame cutting will not be permitted.

G. Installation of Sign Support Structures

Where overhead support structure posts or frames are to be anchored on concrete barriers, the attachment shall be made as shown on the Drawings. No part of the post, frame, base, or concrete support shall extend beyond the inside face of barrier.

Where sign support structures are to be mounted on bridges, the attachment details and location shall be as shown on the Drawings.

The Contractor shall notify the Engineer in writing at least two weeks prior to the date the Contractor intends to erect any sign support structure.

H. Vertical Clearance

The minimum vertical clearance from the lowest point of an independent sign support structure or its attached sign and support system (whichever is the lowest) to the highest point of the highway cross section shall be 5.5 meters unless otherwise shown on the Drawings or directed by the Engineer/MOI's Traffic Department.

704.03.12 Post Mounted Sign Panels

a. Sign panels shall be erected so that the bottom of the sign is as shown on the Drawings, or as directed by the Engineer/MOI's Traffic Department.

b. Extruded panels shall be horizontal, unless specified otherwise, and the panel faces shall be flush within commercial extrusion tolerances after erection of the sign is complete.

c. The shank of the post clip bolts shall fit tightly against the post flange after nuts are torqued tight. Post clips shall be used on both sides of each post at the top and bottom of the sign. Intermediate clips shall be placed on 300 mm maximum centers on each post and shall alternate left to right on each post for sign panels less than 7 meters in width. For signs having a width of 7 meters or greater, the intermediate clips shall be placed on both sides of each post on 300 mm maximum centers.

d. Lock nuts on the 9.5 mm aluminum post clip bolts shall be torqued to 3.66 kN.m when using dry, clean, unlubricated threads.

704.03.13 Truss Mounted Sign Panels

Sign panels shall be mounted on the truss in the manner indicated on the Drawings. Extruded panels shall be horizontal, unless specified otherwise, with the panel faces normal to the center line of the highway and tilted down at a slope of 1 in 25.

704.04 MEASUREMENT AND PAYMENT OF TRAFFIC SIGNS

704.04.1 Basis of Measurement

A. Warning and Regulatory Signs

Measurement for warning and regulatory signs (including posts and foundations for non breakaway posts) shall be by the number of signs installed.

B. Guide Sign Panels

Measurement for guide sign panels shall be by the meter square of face area of panels. No deductions will be made for rounding of panel corners.

Supports, foundations, lighting and other electrical work will be measured separately.

C. Breakaway Support Posts and Connections

Measurement for breakaway posts and truss (where required) shall be by the number of each type. Measurement for the breakaway connections (including breakaway assembly, foundations and the length of post below the breakaway connection) shall be by number of breakaway connections installed for each post type.

D. Non-Breakaway Support Posts

Measurement for non-breakaway posts and truss (where required) shall be by the number of each type (including post and foundation).

E. Overhead Sign Support Structure and Bridge Structure Mounted Sign Support Brackets

Overhead sign support structures and bridge structure mounted sign support brackets shall each be numerated separately, stating the span or the overall width.

Lighting units, including associated fixing brackets, conduit and all other electrical work, are included under Section 14 (Lighting and Electrical Works) of these Specifications

704.04.2 Basis of Payment

A. Warning and Regulatory Signs

Payment for warning and regulatory signs shall be at the Contract rate which shall be full compensation for furnishing all materials, labour, tools, equipment and incidentals necessary to complete the installations.

B. Guide Signs

The supply and installation of electrical fittings for lighting of guide signs, whether ground mounted or mounted on overhead support structure or bridge mounted support brackets, is not included in the following payment items but under Section 14 (Lighting and Electrical Works) of these Specifications.

C. Guide Sign Panels

Payment for guide sign panels acceptably installed shall be at the Contract rate, which shall be full compensation for furnishing all materials, labour, tools, equipment and incidentals necessary to complete the sign panels.

D. Breakaway Support Posts and Connections

Payment for breakaway support posts and truss, and breakaway connections shall be at Contract rate, which rate shall be full compensation for all materials, labour, tools, equipment and incidentals necessary to complete the work.

E. Non-Breakaway Support Posts

Payment for non-breakaway support posts and truss shall be at Contract rate, which shall be full compensation for all materials, labour, tools, equipment and incidentals necessary to complete the work.

F. Overhead Sign Support Structures (Gantries) and Bridge Structure Mounted Sign Support Brackets

Payment shall be at the rates in the Bills of Quantities, which rates shall include for all labour, plant and materials and everything necessary for the proper execution of the work, including all necessary temporary works, testing and other items and work in connection.

The rates for overhead sign support structures (gantries) shall include for excavation in any type of soil including rock and backfilling, plain and reinforced concrete, reinforcing steel, protective membrane, protective painting.

In addition, rates shall include for preparing detailed fabrication drawings for steelwork, including cutting, marking off, drilling, notching, machining, form fitting, edge preparation and cambering; welding, riveting, bolting as the case may be, assembling by any process and pre-heating; all rivets, bolts, nuts and washers required to fabricate the steelwork and to complete the erection and installation of steelwork on Site, together with all spares and service bolts, drifts, draw up cleats and the like specified; routine production tests of welding during fabrication; marking for erection, handling and protecting from damage and transporting to Site; lifting steelwork, erecting and fixing in the final position in the Works including the provision of all temporary supports; aligning and plumbing steelwork, adjusting levels, providing temporary bracings or stays to prevent displacement including the provision of and removal of temporary attachments; making all permanent bolted and welded connections required on Site including the provision of preheat and shelters for welding; all production tests of Site welding.

G. Additional Equipment to be Included

Any additional equipment, material and labour not shown on the Drawings or called for herein and which is required to complete the signs and their support installations will not be measured for payment but will be considered as a subsidiary obligation to the Contractor under this Section.

704.04.3 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
704.1	Warning and regulatory signs	nr
704.2	Guide sign panels	sq.m
704.3	Breakaway for single post sign support	nr
704.4	Breakaway for multiple post sign support	nr
704.5	Breakaway connection for single sign support	nr
704.6	Breakaway connection for multiple sign support	nr
704.7	Non-breakaway post for single sign support	nr
704.8	Non-breakaway post for multiple sign support	nr
704.9	Overhead sign support structure/gantry (span)	nr
704.10	Bridge structure mounted sign support brackets (span/width)	nr

SECTION 8: MATERIALS FOR WATER WORKS

800 - GENERAL

800.01 DESCRIPTION

This Section deals with the Specification of materials required for the construction of the Water Network.

800.02 INFORMATION REQUIRED

The Contractor shall give the name and address of the factories at which the required materials will be manufactured. The Contractor must submit catalogues and a tabulation showing the overall dimensions of each type and size of the required materials, and give an undertaking to deliver the required materials according to the Contractor's construction programme of delivery from the manufacturers.

Before placing an order to the manufacturers, the Contractor shall supply to the MEW/Engineer for approval detailed drawings for all the offered materials complete with specifications and all technical information, and catalogues, in English language, showing:

a. The overall dimensions of each type and size of the offered materials.

b. A confirmation by the manufacturer that materials supplied are according to project Specification and international standards.

Material for waterworks should be compatible with the requirements of MEW or end users / operators. All materials must be obtained from manufacturers/suppliers who are on MEW's list of approved manufacturers/suppliers if available.

800.02.1 Definitions

MEW – Ministry of Electricity and Water

Engineer – As defined in the General Conditions of Contract

Employer – As defined in the General Conditions of Contract

KFSD – Kuwait Fire Services Directorate

800.03 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section. Where no such standards exist, as for example in the case of patented or special materials, all such materials and workmanship shall be of the best quality, and full details of the materials and any tests to which they are subjected shall be submitted to the MEW/Engineer for approval.

BS

BS 10	Flanges and Boltings for Pipes, Valves and Fittings
BS EN 124	Gully Tops and Manhole Tops for Vehicular and Pedestrian Areas - Design Requirements, Type Testing, Marking, Quality Control
BS 336	Fire Hose Couplings and Ancillary Equipment
BS EN 545	Ductile Iron Pipes, Fittings, Accessories and Their Joints for Water Pipelines — Requirements and Test Methods
BS EN 593	Industrial Valves - Metallic Butterfly Valves
BS EN 681-2	Elastomeric Seals Materials Requirements for Pipe Joint Seals Used in Water and Drainage Applications Part 2: Thermoplastic Elastomers
BS 750	Specifications for Underground Fire Hydrants and Surface Box Frames and Covers
BS EN 1057	Copper and Copper Alloys - Seamless, Round Copper Tubes for Water and Gas in Sanitary and Heating Applications
BS EN 1092-2	Flanges and Their Joints - Circular Flanges for Pipes, Valves, Fittings and Accessories, PN Designated - Part 2: Cast Iron Flanges

BS 1400	Copper Alloy Ingots and Copper Alloy Castings
BS EN 1452-2	Plastics Piping Systems for Water Supply - Unplasticized Poly (Vinyl Chloride) (PVC-U) - Part 2: Pipes
BS EN 1452-3	Plastics Piping Systems for Water Supply - Unplasticized Poly (Vinyl Chloride) (PVC-U) - Part 3: Fittings
BS EN ISO 1461	Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles – Specifications and Test Methods
BS EN 1561	Grey Iron Castings
BS EN 1563	Founding-Spheroidal Graphite Cast Iron-AMD 14004
BS EN 1564	Austempered Ductile Cast Irons-AMD 16225
BS 2494	Elastomeric Seals for Joints in Pipework and Pipelines
BS 3416	Specification for Bitumen-Based Coatings for Cold Application, Suitable for Use in Contact With Potable Water
BS 4211	Specifications for Permanently Fixed Ladders
BS 5163	Predominantly Key-Operated Cast Iron Gate Valves for Waterworks Purposes.
BS 5834	Surface Boxes
BS EN 10088	Stainless Steels
BS EN 10090	Valve Steels and Alloys for Internal Combustion Engines
BS EN 12163	Copper and Copper Alloys - Rod for General Purposes
BS EN 13101	Steps for Underground Man Entry Chambers Requirements, Marking, Testing and Evaluation of Conformity
BS EN 14154	Water Meters
BS EN 14901	Ductile Iron Pipes, Fittings and Accessories — Epoxy Coating (Heavy Duty) of Ductile Iron Fittings and Accessories — Requirements and Test Methods

AWWA

C 104	Cement Mortar Lining for Ductile Iron and Grey Iron Pipes and Fittings for Water
C 105	Polyethylene Encasement for Grey and Ductile Iron Piping for Water and Other Liquids
C 111	Rubber Gaskets for Pipelines
C 502	Dry-Barrel Fire Hydrants
C 504	Rubber Seating Butterfly Valves
C 906	Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) Through 63 in. (1,600 mm), for Water Distribution and Transmission

ASTM

A 563M	Standard Specification for Carbon and Alloy Steel Nuts [Metric]
A 568M	Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements

ISO

ISO 161-1	Thermoplastics pipes for the conveyance of fluids - Nominal pressures - Part 1: metric series
ISO 2531	Ductile iron pipes, fittings, accessories and their joints for water applications-Sixth Edition.
ISO 4064	Measurement of water flow in closed conduits; meters for cold potable water
ISO 4427	Plastics piping systems — Polyethylene (PE) pipes and fittings for water supply
ISO 7005-2	Metallic flanges-Part 2: cast iron flanges
ISO 8179-1	Ductile iron pipes external zinc-based coating Part 1: Metallic zinc with finishing layer

DIN

DIN 8061	Unplasticized polyvinyl chloride (PVC-U) pipes - General quality requirements and testing
DIN 8062	Unplasticized polyvinyl chloride (PVC-U) pipes – Dimensions
DIN 8063-1	Pipe joint assemblies and fittings for unplasticized polyvinyl chloride (U-PVC) pressure pipelines; dimensions of socket bends
DIN 8074	Polyethylene (PE) – Pipes
DIN 8075	Polyethylene (PE) pipes - General quality requirements and testing

NSF

Standard No. 14 (1976)

800.04 ENVIRONMENTAL CONDITIONS

800.04.1 General

All materials and equipment proposed for installation as part of this Contract shall be capable of withstanding the environmental extremes experienced in Kuwait at certain times of the year. The Contractor shall familiarize himself with the meteorological data for the Kuwait area and any allied information that may affect the performance of materials and equipment.

Particular attention shall be paid to thermal data, ambient temperatures, salt, air and humidity, corrosion, dust and sand, sun radiation, vermin and fungus.

Temperature extremes for Kuwait are listed for the Contractor's information. These temperatures shall be taken into account in the design and selection of materials and equipment.

800.04.02 Ambient Air Temperature

Maximum July	49°C
Average Maximum	44°C
Mean July, August	37°C
Mean June	36°C
Average minimum July	29°C
Average minimum August	28°C
Minimum January	- 4°C

800.04.3 Sun Radiation Temperature on Black Bulb Thermometer:

Maximum June, July, August	84°C
Maximum January	57°C
Average Maximum June, July, August	74°C
Average Maximum January	48°C

800.04.4 Ground Temperature 1.2 m depth below ground surface:

Maximum August	36°C
Mean August	35°C
Maximum January, February	18°C

The temperature in summer in valve chambers can reach 50°C.

800.05 ANALYSIS OF FRESH WATER SAMPLES

The required materials shall be suitable for use in water pipeline carrying fresh water of a temperature ranging between -4°C and 50°C and the Chemical Analysis shown in the table next page:

Parameter	Concentration mg/l		Parameter	Concentration mg/l
Conductivity	560 (micro s)		Ca	35
PH	7.7		Mg	13
TDS	370		Na	50
C03	0		K	l.6
HC03	16		Sio2	2.2
T.AIK	13		F	0.26
Cl	80		Fe	0.08
S04	130			

801 - MATERIALS

801.01 MATERIALS SUPPLIED BY THE EMPLOYER

Where materials are described hereafter as "Collect from MEW's/Employer's Store" the Contractor shall include in his price for making all necessary arrangements for providing all equipment and labor for loading at the MEW's/Employer's Stores for transporting to site, unloading, storing and fixing in position.

The Contractor's responsibility for material furnished by the MEW/Employer shall begin upon the Contractor's acceptance at the place of collection. All such materials can be examined and tested by the Contractor, and all defective material shall be rejected by him at the time and place of collection.

All material found to be defective or damaged at this time and place will be replaced by the MEW/Employer. Once the material has been accepted by the Contractor at the place of collection he shall be entirely responsible for the material.

All defective or damaged material discovered prior to final acceptance of the work shall be removed by the Contractor and replaced by new and approved material at his own expense. In that event, the Contractor shall furnish all labor, equipment, and material incidental to replacement and necessary for the completion of the work to the satisfaction of the MEW/Engineer.

The Contractor shall be responsible for the safe storage of all material furnished to or by him and accepted by him until it has been incorporated in the completed project and finally accepted by the MEW/Employer. Any material lost or stolen or that otherwise disappears from the Site shall be replaced by the Contractor at his own expense. In the event that materials supplied by the MEW/Employer are lost, stolen or damaged, they will only be replaced by the MEW/Employer if the MEW/Employer has such materials available in Kuwait. The charge for providing replacement materials will be equivalent to the cost of the materials to the MEW/Employer plus 50% of that cost. If the MEW/Employer does not have such materials available, then the responsibility for the replacement materials rests solely with the Contractor and no additional time will be added to the Contract period in respect of the obtaining of these materials.

Materials to be supplied by the MEW/Employer are listed in the Contract Documents.

801.02 MATERIALS TO BE FURNISHED BY THE CONTRACTOR

All materials other than those covered under Clause 801.01 above shall be provided by the Contractor.

The Contractor must supply all materials including ancillaries which are required to complete the works and which are not supplied by MEW/Employer.

The materials provided by the Contractor shall include all materials for temporary works, planking and strutting excavations, shuttering and formwork, staging and scaffolding, land and site drainage if and as required, approved filling materials, approved road surfacing and paving materials, temporary and permanent fencing; all materials required for repairing the internal lining and external coating of pipes and fittings and for external coating of valves, etc., such as primer, coal tar enamel, etc., all concrete of each required class including reinforcing steel and mesh; all manhole covers and frames, surface boxes, pressure reducing valves, step irons, ladders, indicator posts, cable ducts, etc., and all other materials whether of a temporary or permanent nature required in or for the construction, completion and maintenance of the works to the complete satisfaction of the MEW/Engineer.

All materials supplied locally by the Contractor shall be of the best quality in their class and of the respective

kinds as described in the Contract and in accordance with the MEW's/Engineer's directions, and shall be inspected from time to time at the Site during the progress of work.

The Contractor shall, before supplying any materials, prepare and submit to the MEW/Engineer for approval samples of materials which he proposes to employ. Such samples shall be retained by the MEW/Engineer. The materials represented by the samples shall not be used in the works unless and until the samples have been approved in writing by the MEW/Engineer.

All materials furnished by the Contractor shall be delivered and distributed at the Site by the Contractor.

801.03 STORAGE AND HANDLING

Pipes, fittings, valves and accessories shall be loaded and unloaded by lifting with hoists or skidding so as to avoid shock or damage. Under no circumstances shall such materials be dropped. Pipes handled on skidways shall be prevented from knocking against the ground.

801.04 PACKING

The materials shall be packed in a sea-worthy manner to prevent any damage or loss during loading, off-loading, and transportation, and the rates shall include cost of such packing.

801.05 MATERIAL SUPPLIED AS SPARE PARTS

If the Bills of Quantities includes items for supply of materials as spare parts, the Contractor shall make all the necessary arrangements for the conveyance of these materials upon arrival to Kuwait to the MEW's/Employer's stores.

The Contractor shall be solely responsible for unloading and stacking all materials upon arrival at MEW's/Employer's stores.

802 - RESPONSIBILITY FOR MATERIALS

802.01 RESPONSIBILITY FOR MATERIALS FURNISHED BY THE EMPLOYER

The Contractor's responsibility for materials furnished by the MEW/Employer shall begin upon his acceptance at the point of delivery. Once accepted by the Contractor, all materials found to be defective or damaged prior to final acceptance of the work shall be removed by the Contractor and replaced at his own expense, to the satisfaction of the MEW/Engineer.

802.02 RESPONSIBILITY FOR MATERIALS FURNISHED BY THE CONTRACTOR

The Contractor shall be responsible for all materials he furnishes and shall replace at his own expense all such material found to be defective or damaged. This shall include the furnishing of all materials and labor required for the replacement of installed material discovered to be defective prior to the final acceptance of the work.

802.03 RESPONSIBILITY FOR SAFE STORAGE

The Contractor shall be responsible for the safe storage and protection of all materials furnished by or to him under the Contract, and the MEW/Engineer shall neither accept responsibility nor consider any claim in respect of any damage, loss or theft etc., which may affect or delay the course of the Contract. Particular attention should be given to the protection and storage of pipes, fittings, valves, etc., both in the pipe yard and on Site to avoid damage to the protective coatings and linings and the MEW/Engineer reserves the right to order, at the Contractor's expense, additional protective measures, should he deem them to be necessary.

802.04 INSPECTION, TESTING AND REJECTION

The MEW/Engineer shall be entitled at all reasonable times during manufacture to inspect, examine and test on the Contractor's premises the materials and workmanship of all items to be included in the Works of these Specifications, (which shall include all pipeline materials to be provided by the Contractor as specified in Clause 801.02 of these Specifications) and if part of the items are being manufactured on other premises, the Contractor shall obtain for the MEW/Engineer permission to inspect, examine and test as if the said items were being manufactured on the Contractor's premises. Such inspection, examination, or testing, if made, shall not

release the Contractor from any obligation under the Contract and will not entitle him to claim any extension of the delivery period specified in the Contract.

The Contractor shall give the MEW/Engineer a minimum of twenty days written notice of the date on which, and the place at which, any of the items will be ready for testing as provided for in the Contract and unless the MEW/Engineer shall attend at the place so named within twenty one days after the date which the Contractor has stated in his notice, the Contractor may proceed with the tests, which shall be deemed to have been made in the MEW's/Engineer's presence, and shall forthwith forward to the MEW/Engineer four duly certified copies of the test readings. The MEW/Engineer will give the Contractor 24 hours' notice in writing of his intention to attend the tests.

Where the Contract provides for tests on the premises of the Contractor or of any subcontractor, the Contractor shall, except where otherwise specified, provide such assistance, labor, instruments and such other things as may be requisite and as may be reasonably demanded to carry out such tests efficiently.

If after inspecting, examining, or testing any of the items, the MEW/Engineer shall decide that such item is defective or not in accordance with the Contract, he may reject such part by giving notice in writing of such rejection to the Contractor within a reasonable time, stating there in the grounds upon which the said decision is based.

Where the Contract provides for tests of the items, or any part thereof when completely manufactured; such tests shall, in the absence of any arrangements to the contrary, take place on the premises of the Contractor.

The Contractor shall give the MEW/Engineer a minimum of fourteen days notice in writing of the date on which the items are ready to be packed and shipped. Unless the MEW/Engineer attends the place so named on the date which the Contractor has stated in his notice the Contractor may proceed with the packing and shipping and shall forward forthwith to the MEW/Engineer four (4) duly certified copies of the shipping documents.

The MEW/Engineer shall give to the Contractor 24 hours notice in writing of his intention to inspect the items before packing.

802.05 GENERAL

The Contractor is not allowed, without the permission of the MEW/Engineer, to transport any material or equipment from the Site for use outside the Contract.

803 - PIPES, VALVES AND FITTINGS

803.01 PIPES

803.01.1 Ductile Iron Pipes

803.01.1.1 General

All ductile cast iron pipes shall comply fully with the requirements of the latest edition of ISO 2531, BS EN 545 or equivalent. The pipes shall be centrifugally cast in metal or sand-lined moulds with sockets for push-on joints. Unless otherwise indicated in the Bill of Quantities or the Drawings, Class K9 shall be used.

All pipes shall be heat treated. Detailed and technical specifications for the offered materials shall be submitted together with the latest edition of the Standard Specification of the offered materials

803.01.1.2 Chemical and Physical Tests

The minimum physical characteristics of the pipes shall be as specified in ISO 2531.

803.01.1.3 Dimensions, Weights and Lengths

These shall be according to the requirements of I.S.0 2531and BSEN 545 specification latest edition.

803.01.1.4 Markings

Each pipe shall be indelibly marked as per the requirements of ISO/BSEN to show diameter in mm,

manufacturer, standard, the date of manufacture, the pressure rating/ K class and the letters MEW which represent Ministry of Electricity and Water.

803.01.1.5 Quality Control

The MEW/Employer or his representative shall be provided with the opportunity to inspect the pipes at the place of manufacture by being given at least two weeks' notice of the time at which the pipes are to be supplied.

Inspection will also be made visually when the pipes arrive at the MEW's/Employer's or Contractor's Store.

803.01.2 uPVC Pipes

803.01.2.1 General

Plastic pipes shall be extruded, rigid unplasticized PVC, complying fully with DIN 8061/8062 or BS EN 1452-2 or ISO 161. The pipes shall be with preformed ends with socket for push-fit joining. The pipes shall be suitable for fresh/ drinking water conveyance and shall not be used for above ground or exposed application.

803.01.2.2 Rating / Class

The pipes shall be of class 16 (series 5) rated for use with water at 20°C (min.) temperature at a maximum sustained working pressure of 16 kg/cm^2 (160 meter head of water),

803.01.2.3 Workmanship and Color

The pipes shall be homogenous throughout and free from cracks, holes, foreign inclusions or other defects. It shall be uniformly grey in color and uniform in opacity, density and other physical properties.

803.01.2.4 Dimensions

The pipe dimensions shall be designated by the nominal size and outside diameter. Pipes shall be supplied in standard lengths.

803.01.2.5 Rubber Rings

The rubber rings used for joining shall comply in its components with BS 2494 and shall be suitable for climatic conditions in Kuwait.

803.01.2.6 Tests on uPVC Compounds

Where uPVC is used for potable water, the uPVC compounds in pipes and fittings shall contain no ingredients in an amount that has been demonstrated to migrate into water in quantities considered to be toxic. uPVC compounds shall be tested and certified suitable for potable water by the National Sanitation Foundation (NSF) Testing Laboratory – USA, or the Canadian Standard Association (CSA) Testing Laboratory, or other accredited testing agency. Tests shall be made in accordance with requirements no less restrictive than those in the NSF Standard No. 14 (1976), Sections 3 and 4. The seal and mark of the testing laboratory shall be included on pipes and fittings.

803.01.2.7 Marking

All pipes shall be continuously and permanently marked as stated in Clause 803.01.1.4 of these Specifications.

803.02 FITTINGS

803.02.1 Ductile Iron Fittings

803.02.1.1 General

The material for the fittings shall be the same as for ductile iron pipes and its properties and testing shall comply with the requirements given in the relevant standard specification. The fittings shall be supplied with either sockets for rubber rings, mechanical joints or with push-on joints. The fittings shall withstand a working pressure equal to the pipe working pressure.

803.02.1.2 Hydrostatic Tests

The fittings shall be designed to withstand the hydrostatic test pressure at works equal to 1.5 x the working pressure.

803.02.1.3 Chemical and Physical Tests

Tests shall be made and statements furnished as described in BS EN / ISO specification.

803.02.1.4 Dimensions, Weights and Lengths

These shall be according to the requirements of BS EN / ISO specification latest edition.

- K 12 for fitting not including Tees.
- K 14 for Tees.

803.02.1.5 Markings

Each fitting shall be indelibly marked as described herein for ductile iron pipes.

803.02.1.6 Quality Control

The MEW/Employer or his representative shall be provided with the opportunity to inspect the fittings at the place of manufacture by being given at least two weeks' notice of the time at which the fittings are to be supplied.

Inspection will also be made when the fittings arrive at the MEW's/Employer's or Contractor's Store.

803.02.2 uPVC Fittings

803.02.2.1 General

All uPVC pipe fittings shall be injection moulded fittings manufactured of the same material as the pipe and shall be suitable for push-fit or flanged joining. The fittings shall comply fully with the requirements of BS EN 1452 part 3 or DIN 8063 part 1 fabricated from pipe. The fittings shall be supplied with rubber rings, and flange adapters. No solvent cement joining shall be permitted.

803.02.2.2 Rating / Class

uPVC fittings shall be suitable for use with uPVC pipes of class 16 (Series 5) having a maximum continuous pressure rating of 16 , at 20°C (min.) water temperature.

803.02.2.3 Hydro-Static Tests

uPVC fittings shall conform to hydro-static pressure requirements of the relevant standard specifications. In general the fittings shall withstand a test pressure equal to 3-6 times the working pressure for 1 hour without failure.

803.02.2.4 Appearance and Marking

The internal and external surfaces of all fittings shall be clean, smooth and reasonably free from grooving and other defects. All fittings shall be marked as given under uPVC pipes.

803.02.2.5 Nuts & Bolts

Nuts & Bolts shall be carbon steel conforming to BS 10 Ref. III for flanged end fittings and adapters.

Note:

Alternatively, C.I. Fittings coated with P. V. C. *or plastic can be used/offered, but conforming to the above Clauses and to suit the uPVCPipes.*

803.03 JOINTS

803.03.1 Joints in Ductile Iron Pipes & Fittings

803.03.1.1 General

Ductile iron pipes shall be supplied with push-on joints.

Ductile iron fittings, unless otherwise specified, shall be supplied with mechanical joints consisting of a bolted gland with a rubber gasket, which shall comply where applicable with the requirements of ISO standards. The nominal thickness of the socket shall not be less than the nominal wall thickness of the pipe. Fittings of 600 mm dia. and smaller (except Flanged/SOC adaptors, Collars, End caps) can be supplied with push on joints.

Details of the joint design shall be in accordance with the manufacture's standard practice and catalogues. The dimensions and weights of glands and bolts and gaskets shall be specified by the Contractor.

The Contractor shall supply everything necessary for the joints; such as glands, gaskets, bolts and nuts.

803.03.1.2 Glands

Glands shall be made of ductile cast iron of the same quality as for the fittings. Tensile tests and hardness tests of the material shall be made in compliance with the offered standard.

Should the gland not pass these tests, judgment of the tests conducted and their results shall be made in the same way as stated for ductile iron pipes.

The manufacturer's name or identification mark, the date of manufacture and the nominal diameter shall be clearly marked on a fixed spot on the outside of each gland.

Glands shall be supplied coated with a bituminous coating not less than 0.1 mm thick.

803.03.1.3 Rubber Gaskets

Rubber gaskets shall conform to AWWA C111 or BS 2494 latest edition and shall be suitable for the climatic conditions in Kuwait and for a water temperature of 48^{o}C.

803.03.1.4 Bolts and Nuts

Unless otherwise shown in the Contract Documents, bolts shall be to ASTM A 568M, grade 8.8, with heavy hex nuts to ASTM A 563M.

Outer surfaces except the threaded part shall be coated externally in the same way as specified for the fittings under Clause 803.07.2 of these Specifications.

Two test pieces shall be taken out of each lot of 500 pieces or less. These pieces, bolt and nut assembled, shall be tensile tested. The test load shall be not less than 215N/mm^2 calculated on the nominal size of the bolt.

On the bolt's head the manufacturer's name or identification mark shall be clearly marked.

803.03.1.5 Quality Control

The Contractor shall furnish the MEW/Engineer with three copies of reports giving the results of all the tests carried out on glands, gaskets and bolts.

Inspection of the joint constituents will be made on their arrival at the MEW's/Employer's or Contractor's Store.

803.03.1.6 Locked or Restrained Joints

A certain number of pipe lengths and fittings shall be supplied and be suitable to accept restrained couplings. This type of coupling shall be equipped to accept axial thrust forces working on bends, valves, tees, tapers and dead ends.

The thrust resisting mechanism shall be separated from the sealing action of the rubber ring seals.

The joint when assembled must be capable of transmitting the tensile load arising when the complete cross-sectional area of the Pipe bore is obstructed when the internal water pressure in the pipe is 10 kg/cm2s. The Contractor shall submit full details of the type of retrained coupling he proposes to use. For the approval of the MEW/Engineer.

Calculation of the number of pipe lengths with retrained couplings required, following the manufacturer's recommendation, shall be submitted for approval. These shall take into consideration that during testing all joints are exposed and only primary backfill is placed on the pipe

The calculation shall be based on the following conditions:

- Depth of earth cover 1 m. .
- Hydraulic test pressure 1.5 x working pressure but not less than 10 kg/cm2s
- Density of soil 'dry' 18 KN/M^3
- Density of soil 'wet' 20 KN/M^3.

803.03.2 Joints in uPVC Pipes & Fittings

uPVC pipes shall be supplied with push-on joints. Fittings shall be suitable for push-fit or flanged joining. No solvent cement joining shall be permitted.

Joints shall be to DIN 8063 part 1, socket spigot with rubber sealing rings shall be to BS EN 681-2. Details of the joint design shall be in accordance with the manufacture's standard practice and catalogues. The dimensions and weights of glands and bolts and gaskets shall be specified by the Contractor.

The Contractor shall supply everything necessary for the joints; such as glands, gaskets, bolts and nuts.

803.04 FLANGED FITTINGS AND FLANGED PIPES

803.04.1 Fittings and Pipes

All fittings and pipes with flanged ends of 600 mm. and smaller shall be drilled to BS 10, Table E, unless otherwise specified.

All fittings and pipes 800 mm and larger shall be drilled to ISO. Table NP 10 unless otherwise specified.

803.04.2 Bolts and Nuts

Bolts and nuts shall be of galvanized mild steel.

803.04.3 Gaskets

Gaskets shall be of rubber reinforced with cotton of thickness not less than 3 mm.

803.05 POLYETHYLENE ENCASEMENT

Polyethylene sleeves shall conform to Class C of AWWA C105 latest edition.

803.06 INSTALLATION OF PIPES AND FITTINGS

The methods specified in Section 9 (Water Pipeline Construction) of these Specifications shall be followed for the installation of pipes and fittings.

803.07 PROTECTION OF DUCTILE IRON PIPES AND FITTINGS

803.07.1 General

Pipes and fittings shall be coated externally with a metallic zinc coating or zinc rich epoxy paint before applying a coal tar or bituminous compound of thickness conforming to Clause 803.07.2 of these Specifications.

Pipes shall have a cement mortar lining and a seal coat in accordance with AWWA C104-64 double thickness.

803.07.2 External Coatings for Pipes and Fittings

Pipes and fittings shall be coated externally with a 20 microns thick metallic zinc coating before applying coal tar or a bituminous compound, pigmented with aluminum of thickness not less than 100 microns. Alternatively, the Contractor may propose zinc rich epoxy paint at least 100 microns thick in place of the metallic zinc. The metallic zinc or the alternative as mentioned and their application shall be according to the ISO./DIN 8179-1.

Internal surfaces of socket, and external surfaces of spigot ends up to 250mm, shall be coated by 2 pack solvent free epoxy resin of thickness to manufacturer's specification but not less than 100 microns and be in contrasting colors. An alternative can be suggested provided that it gives the extra protection required.

803.07.3 Internal Coating for Pipes and Fittings

803.07.3.1 Cement Lining

The internal coating shall be according to AWWA C104 (double thickness and as stated herein). The cement shall meet the requirements for Type II Portland Cement as described in Section 5 (Concrete Works) of these Specifications. There shall be no cracks in the cement lining.

The thickness of lining for pipes shall not be less than :

3.2 mm for pipe sizes from 60 mm up to 300 mm

4.8 mm for pipe sizes from 350 mm up to 600 mm

6.4 mm for pipe sizes from 700 mm up to 1200 mm

803.07.3.2 Seal coat

Seal coat shall be according to AWWA C104. The material used for the seal coat shall not contain phenols or any other constituent soluble in water and, after drying for at least 48 hours shall have no deleterious effect upon the quality, color, taste or odour of potable water of a temperature of at least 50^{o}C that has been left standing in the pipe for 48 hours.

803.07.4 Alternative External and Internal Coating to Fittings

As an alternative fittings can be coated wholly internally and externally by epoxy of thickness not less than 150 microns and of quality suitable for drinking water of a temperature about 48^{o}C. The coating should comply with BS EN 14901. Details of coating material should be given by the Contractor for approval by the MEW/Engineer.

803.07.5 Test and Inspection

Tests shall be carried out according to AWWA C104. Tests on taste and odor shall be done with heated water at a temperature of at least 50^{o}C.

Certificates by an authorized institute shall be presented to the MEW/Engineer for approval before application of the seal coat.

The MEW/Engineer or his Representative shall be provided with the opportunity to inspect the pipes at the factory by being given at least two weeks notice of the time at which the run is to be made.

803.08 VALVES

803.08.1 General

All Butterfly Valves, Sluice Valves, Pressure Reducing Valves, Air Valves required under this Clause shall be supplied according to the following Specifications.

Unless shown otherwise in the Contract Documents, flanged end connection for all valves shall be to BS EN 1092-2 and drilling of flanges shall be to ISO 7005-2 or BS 10, Table E.

A complete set of bolts and nuts and one gasket shall be supplied for each flange. Gaskets shall be of rubber reinforced with cotton and of thickness not less than 3 mm.

Face to face dimensions for butterfly valves and sluice valves shall be as given in Clause 805of these Specifications.

The Contractor shall submit detailed information and technical information on the design of each Type of valve he is required to supply under the Contract for MEW's/Engineer's approval.

803.08.2 Butterfly Valves

A. General Requirements

Valves from 400 mm diameter and above shall be manually and electrically operated (provided with an actuator), double flange with resilient seating, for horizontal use without a by-pass in accordance with BS EN 593 or AWWA C504. For valves operated by hand wheel the maximum shut off pressure against which valve is operated is to be 15 kg/cm². The valves shall be suitable for flow in either direction and shall be designed to be used as "regulating and closing" valves.

Valves shall be supplied complete with the mechanical operators, hand wheels and extension rods with caps and other accessories for operation from inside and from outside of the manholes in which the valves shall be installed.

B. Class

The valves, unless otherwise specified, shall be suitable for a working pressure equivalent to 16 kg/cm2s.

C. Performance

The valves shall have flanged ends. Flanges shall be drilled and finished with a bolt circle diameter in accordance with ISO NP 10 unless otherwise specified. Unless otherwise shown in the Contract Documents, bolts and nuts shall be according to BS 10, carbon Steel, Ref. III or equal.

D. Body

The body of the valves shall be of ductile cast iron to BS EN 1563 Grade 420/12 or 500/7.

E. Shaft

Valves shafts shall be of stainless steel type 316-S16 {2.1/2% Molybdenum} as specified in BS EN 10090. The design of the shaft shall be such that it will safely sustain maximum differential pressures across the closed valve, and it shall be capable of withstanding the maximum torque required to operate the valve as specified in BS EN 593 & AWWA C504.

F. Seats

Valve body seats shall be made of stainless steel type 316-S16 (2.1/2% Molybdenum) as specified in BS EN 10090.

G. Stuffing Boxes

Stuffing boxes shall be made of ductile cast iron.

H. Discs

Valve discs shall be of ductile cast iron of a quality not less than BS EN 1563 Grade 500/7.

I. Indicators

Valves shall be provided with some form of indication of the position of the disc.

J. Packing

Packing shall be easily maintained and renewed. If lubrication is necessary, easily accessible fittings shall be provided.

K. Operation

The valves shall be capable of being seated and unseated under the most adverse conditions appropriate to their ratings. The valves shall be supplied with torque requirements for hand operation. The hand wheel shall have a diameter not less than 400 mm. Two sets of operating devices shall be delivered for each size of valve. All butterfly valves shall be installed in valve chambers. Four keys shall be delivered for each size of valve.

L. Protection

Valves shall be protected internally and externally by epoxy resin coating of not less than 150 microns thickness.

M. Tests

Each valve shall be tested according to the relevant standard specification and the MEW/Engineer shall be supplied with the records of all tests.

803.08.3 Sluice Valves

A. General Requirements

Valves with a diameter from 50 mm to 600 mm to BS 5163, inside screw, solid wedge, (resilient seated for valves 350 mm and smaller, and metal seated for valves 400 mm and larger), bolted bonnet, non-rising stem type.

B. Class

Unless otherwise specified the valves shall be designed for a working pressure of 16 kg/cm2s and shall withstand in open position a test pressure appropriate to the working pressure.

C. Materials

The valve components shall be manufactured from basic or alternative materials listed in BS 5163 in general and in particular the following materials :

Body Ductile Cast Iron

Stem High tensile brass of aluminum bronze

Facing Rings and Stem Nuts Gunmetal to BS 1400-LG2 or equivalent.

D. Performance

The valves shall be of ductile cast iron, hand-operated, double flanged or double socket as specified.

The extension spindles shall be provided with cast-iron caps for operation by a removable key.

Unless otherwise shown in the Contract Documents, flanges of the valves shall be in accordance with ISO 7005-2 or BS 10, Table E.

Unless otherwise shown in the Contract Documents, bolts shall be to ASTM A 568M, grade 8.8, with heavy hex nuts to ASTM A 563M.

E. Operation

Valves shall be hand operated unless otherwise specified. Ten keys shall be delivered for each size of valve.

F. Protection

Valves shall be protected internally and externally by an epoxy resin coating of thickness not less than 150 microns.

G. Tests

Each valve shall be tested according to the relevant standard specification and the MEW/Engineer shall be

supplied with the records of all tests.

803.08.4 Air Valves

A. General Requirements

Air valves shall be ductile cast iron, double orifice valves with one small orifice for release of air accumulating under normal working conditions and one large orifice for release and admission of air when filling and emptying the water mains respectively or single orifice only as shown on the Drawings.

B. Class

Unless otherwise specified, the air valves shall be designed so that the small orifice will operate and release air at any pressure up to at least 16 kg/cm2s.

The valves shall withstand a tests pressure equivalent to twice the working pressure.

C. Performance

The valves shall have flanged ends. Unless otherwise shown in the Contract Documents, flanges of the valves shall be in accordance with ISO 7005-2 or BS 10, Table E.

Unless otherwise shown in the Contract Documents, bolts shall be to ASTM A 568M, grade 8.8, with heavy hex nuts to ASTM A 563M.

D. Operation

Air Valves shall have an internal screw-down isolating valve to permit inspection of the valve without shutting off the main. The stainless steel or hard rubber floating ball shall be designed so that the large orifice may in no case be prematurely closed by the actions of the air stream escaping from the water main.

All air valves shall be installed in valve chambers.

E. Protection

Valves shall be protected internally and externally by epoxy coating of thickness not less tan 150 microns.

F. Tests

Each valve shall be tested according to the manufacturer's and/or relevant standard specification and the MEW/Engineer shall be supplied with the records of all tests.

803.09 HYDRANTS

A. General Requirements

Hydrants shall be the screw-down underground type in accordance with BS 750 at residential areas and dry barrel, post type to AWWA C502 at remaining areas especially commercial areas and Highways/Motorways, Post type hydrants shall be of the tilt off version, and shall be provided with intermediate seal bush to guarantee leak tightness in case of breakage due to traffic accidents. The bury-length (cover depth) from the top of water main up to ground line shall be 1.0 to 1.2 meters. The post type hydrant shall have one main 4" (100 mm) pumper outlet and two exposed hose outlets of 2.5" (62.5 mm) size fitted with c\globe barrel hydrants and with 2.5" (62.5 mm) diameter instantaneous coupling to BS 336 of single pull release. The globe barrel hydrants shall be supplied with hand wheel. The 4" (100 mm) outlet shall be with round thread to B.S. 336 and supplied with the required cap. The cap and couplings shall be chained securely to the hydrant barrel with a metal chain conforming to BS 336. Inlet to the hydrant from the main shall be through a flanged inlet from the side of a minimum 150 mm dia.

All hydrants shall be as shown in the Particular Specifications and Drawings and shall be to the current requirements of the Kuwait Fire Department (Brigade). The Contractor shall submit detailed information on the design of the hydrant for the approval of the MEW/Engineer/KFSD.

B. Class

Unless otherwise specified, the hydrant shall be designed for a working pressure of 16 kg/cm2s and shall withstand test pressures appropriate to the working pressure.

C. Materials

Material for post type hydrants shall be any materials stipulated in AWWA C502 except that materials identified as being subject to de-zincification or de-aluminumization shall not be used.

Unless otherwise shown in the Contract Documents, inlet flanges for underground hydrants shall be 3" Flanges, and shall be dimensioned and drilled in accordance with BS 10, Table E, and shall be faced without recess, complete with gaskets, bolts and nuts.

Unless otherwise shown in the Contract Documents, bolts and nuts shall be in accordance with BS 10, Carbon Steel Ref. III and the gasket shall be 1/8" thick made of rubber reinforced with cotton with properly formed bolt holes. The hydrant shall be made of D.I. or Meehanite C.1. to BS EN 1561 Gr. 17 min or similar approved.

D. Testing

Each hydrant shall be tested according to the relevant standard specification and the MEW/Engineer/KFB shall be supplied with the results of all tests.

E. Operation

All hydrants shall be hand operated and one set of keys shall be supplied with each hydrant.

F. Protection

Hydrants shall be protected in accordance with the Contract Documents, bearing in mind the severe climatic conditions to which they will be subjected.

G. Surface Box to BS 750 for Underground Hydrant

The clear opening of the box shall be 230mm x 380mm x 115mm deep. The 115mm hydrant cover shall be clearly marked with the letters “(F.H.)”, 75mm high, cast into the cover.

The underside of the hydrant box shall be fitted with a 75mm circular white vitreous enameled plate, bearing in black 19mm lettering the word (OPEN) with a black arrow indicating the direction the key should be turned to open the valve.

803.10 ELECTRO MAGNETIC FLOW METERS

A. General

The flow metering system will be of latest technology of microprocessor based with new state-of-art electronic technology and suitable for integrated water measurement system. It should be capable of measuring 'flow rate, total flow, pressure in both forward and reverse direction and data logging within single unit. The system should have facility to connect external pressure transducer by quick fit connector.

The flow meter shall have no moving parts and shall be powered by battery that will give at least 3 years continuous flow and pressure measurement.

The accuracy of the flow meter system shall be better than the regulations of ISO 4064 class C and CEN Pr, EN 14154 with 1000:1 measuring range. The performance table from the manufacturer must be submitted for the approval of the MEW/Engineer.

The flow metering system shall feature empty pipe sensing with all output to drive down scale during an empty pipe condition.

The flow metering system shall offer a stable zero for life so that routine zeroing is not required.

The sensor and electronic unit shall be fully interchangeable only by change in configuration..

All materials should be submitted to the MEW/Engineer in the form of a technical submittal for approval before proceeding for purchase. All materials must be inspected and approved by the MEW/Engineer before installation.

The flow meter shall be installed at remote locations and sensor should be buried. Both will be worth protection grade of IP 68 (submersible). Sensor terminal box & electronics should be filled at factory with potting material with cable.

The flow meter system should be suitable for operating temperature range -05°C to 70°C at pressure up to 16 kg/cm2s.

Dual alpha numerical LCD shall indicate flow rate, units, direction of flow, total flow, pressure etc. There should be also indication for battery low, fault, empty pipe etc.

The system shall have data logging facility for multi channel, multi parameter and with variable speed of logging. The system should have advanced automatic time synchronization feature. The system should have minimum 365 days memory capacity to record for one year.

The system should be provided for all the related cables. Military type connectors as well as Mil-spec connectors, pressure transducer connectors, laptop connectors, downloading cables etc.

The system should be also provided with suitable software which is most commonly used and compatible with all devices, easy to download data and transfer to excel, graphics or any existing software.

The system should have the remote communication facility with integral GSM & GSM-SMS for on-line diagnostics, configuration and data retrieval with RS 232.

The Contractor shall give the name and address of the manufacturer's factory with copy of catalogue and detailed specification in English language.

12 months extended warranty shall be required against any manufacturing defects.

The Contractor shall arrange third party inspection for factory acceptance test (FAT) at the place of manufacturing unit.

The housing box shall be GRP, single door, modular design, lightweight, strong, weather resistant, water resistant, vandal resistant, rust free and maintenance free. Door should provide the maximum access and designed to carry maximum load. The housing box shall have a separate base unit of GRP, which shall be installed with concrete. The base shall have cable access. The GRP housing box shall have external gel coat of ophthalmic polyester pigment to semi gloss finish. The internal finish should be of pigmented white flow coat.”.

B. Sensor

Material	:	Carbon steel
Lining Material	:	Elestomer for potable water
Electrode Material	:	SS 316 L
Protection	:	IP-68 (Submersible & Buriable)
Earthing Rings	:	SS 316
Working Pressure	:	16 Kg/cm2 Max
End Connection	:	In accordance with BS 10 Table E
Calibration	:	Standard 3 point with pressure Test
Cable Length	:	30 meter potted on sensor side suitable for buried application

C. Electronic Unit

Mounting	:	Remote with in 30 meter from sensors
Housing Material	:	Aluminum Alloy
Protection	:	IP-68 (Submersible)
Power supply	:	Battery operated
Display	:	9 Digit LCD Display with indication of Flow rate, Forward & Reverse, Flow, net flow velocity
Flow velocity	:	Pressure indication, battery low, battery A&B

Failure	:	Icon, empty pipe alarms etc.
Flow Unit	:	Selectable IGPD, IGPH, GPM
Velocity Unit	:	Meter/seconds
Pressure Units	:	Selectable MWC, Kg/cm^2
Intermitted Interval	:	15 Seconds
Local Port	:	RS-232
Remote Port	:	RS-232 with Internal GSM Modem
Language	:	English
Data logger memory	:	365 days
Pressure Connection	:	Standard Quick-fit (Military Type)
Pressure Cable Length	:	30 Meter

Batteries:

Type	:	Lithium (Integral)
No. of Batteries	:	2 per unit
Capacity	:	3 years continuous measurement (Note: Production date not more than 6 months before shipping date)

D. Calibrators (Quantity required 2 units)

Flow Calibrators	:	Standard velocity feeding to cover all the ranges.
Pressure Calibrators	:	Standard transducer signal feeding to cover all the Ranges.

E. Portable PC (Quantity required 1 piece)

Latest version portable PC with all necessary software and connectors for all type of configuration and settings.

F. Pressure Sensors

The pressure sensor should be connected to the transmitter with a standard quick fit connector. The pressure has to be as per the rating of the flow sensor.

G. Installation

- The sensor will be installed by the Contractor but under the supervision of MEW/ Engineer.
- It will be Contractor's responsibility to co-ordinate with the MEW /Engineer for the shutdown of existing line, schedule of work and installation of flow meter. The Contractor's team with engineer and supervisor must visit the site along with mechanical contractor for survey for each flow meter and submit the report and drawing to MEW/Engineer prior to the installation of flow meter.
- The housing box shall be installed with concrete foundation at the place approved by MEW/ Engineer.
- The buried cable shall be installed through PVC coated metal conduit (UL approved) with bush fittings on both sides. The foundation must have GI conduit sleeve, which shall be sealed by waterproof compound after installation of cable.
- The Contractor shall be responsible for draining the existing lines for the installation of the flow meters. Accordingly the equipments like Diesel Pumps; temporary pipes shall be arranged by the Contractor.

H. Testing & Commissioning

- All the calibration work will be fully supervised buy MEW/Engineer. Contractor will ensure himself for the calibration before executing calibration work in witness of MEW/ Engineer. Any failure in completing the calibration work in witness of MEW/ Engineer can be penalized to the Contractor.
- The Contractor will arrange the manufacturer's representative for the commissioning of all flow meter as per MEW schedule of commissioning.
- Standard test and commissioning formats approved by MEW/ Engineer shall be filled in and have them certified by MEW/ Engineer after testing and commissioning of the flow meter system.

- All as-built drawing shall be submitted in 5 digital and hard copies after completion of all commissioning.
- All the test equipments, connectors and portable PC shall be handed over to MEW after completion of the work.

I. Warranty

- There will be a 12 months warranty period after the commissioning & acceptance of all system by MEW/Engineer.

J. Housing Box

Material	:	GRP-3 layers composite construction
Type	:	Single door with base frame.
Dimension	:	As shown on Contract Drawing
Color	:	Blue
Protection	:	IP-55 with self ventilation
Facility	:	Handle with door lock, door should carry master lock.

803.11 PRESSURE REDUCING VALVES

A. General

The Pressure Reducing valves are required for use in Fresh and Brackish Water pipelines and shall be relay-operated type. It shall reduce a constant or variable inlet pressure to a predetermined constant outlet pressure, at flows varying from the maximum capacity of the valves to zero flow.

Adjustments of the outlet pressure can be made by the screw on the relay valve.

The valves shall be capable of reducing from 16 -3 kg/cm2 inlet pressure, down to16 -2 kg/cm2 outlet pressure and shall close tight at no flow conditions.

Pipe work shall be interchangeable from right hand side to left hand side restrict needle valve with one connection to upper cylinder via calibrated needle valve.

Further connection to an adjustable relay valve and pressure gauge to downstream enabling valve to be adjusted to give the required downstream pressure.

All ports (inlet, outlet, etc.) of the valve body shall be fully lined with gunmetal to BS1400-LG2. Main valve shall be fitted with calibrated position indicator in cover for guidance. Cover of the valve shall be drilled / tapped and fitted with automatic single acting air valve 1" diameter with non-return feature to release air under pressure, in addition to a manual operated Gunmetal air release cock.

Main valve shall be supplied complete with two sealed pattern pressure gauges (inlet & outlet).

Unless otherwise specified drilling of flanges for valves shall be according to BS 10, Table E.

A complete set bolts and nuts and one gasket shall be supplied to each flange.

Bolts and nuts shall be according to BS 10, Carbon Steel, Ref. III or equal.

Rubber gaskets shall be rubber reinforced with cotton and of thickness not less than 3mm with properly formed bolt holes.

Detailed information and Technical data and chemical compositions of the various alloy components should be submitted.

Consideration will be given to those materials containing the minimum amount of zinc.

B. Materials

• Body, Cover & Piston.	➢ Ductile Cast Iron or good quality Meehanite Cast Iron with grade not less than 260 to BS EN 1561
• Cylinder Liner	➢ Gunmetal to BS 1400-LG2
• Valve Ring, Seat Ring and Retaining Ring	➢ Gunmetal to BS 1400-LG2
• Seal Housing & Bracket	➢ Gunmetal to BS 1400-LG2
• Guide Nut & Bushes	➢ Gunmetal to BS 1400-LG2
• Control Restrictor, Needle Valve, Relay Valve and Isolating Cocks are fully	➢ Gunmetal to BS 1400-LG2
• Bolts & Nuts	➢ Stainless Steel to BS EN 10088 Grade 431 S 29
• Indicator	➢ Forged A1-Bronze to BS EN 12163
Note ***Mild Steel is prohibited*** *All By-pass pipe work shall be in heavy gauge copper to BS EN 1057 or equal and plastic coated, and all isolating cocks shall be of Gunmetal 1400-LG2 and with captive valves.*	

C. Dimensions and Class

The Contractor must submit detailed drawings and catalogues showing the overall dimensions of valves for approval by the MEW/Engineer before ordering the material.

The valve unless otherwise specified shall be suitable for a working pressure equivalent to 16 Kg/cm^2 and shall be hydrostatically tested to a pressure of 24 Kg/cm^2.

D. Other Requirements

The valves shall be supplied complete with relay system, pressure gauges and all other accessories ready for installation.

Valves shall be protected internally and externally by epoxy coating of Dry Film Thickness (DFT) not less than 150 microns.

Generally the internal and external coating shall be suitable for water temperature of 50°C, and ambient temperature of 85°C and Internal and External D.I. / or C.I valve surface must be well cleaned and prepared before any coating is applied.

E. Spares

Complete list for spare parts for 2 years maintenance shall be submitted by the Contractor.

F. Guarantee

Valves shall be guaranteed against defects for 2 years.

G. Hydraulic Tests

All valves shall be tested by water to 13.5 kg/cm2.

H. Marking

Each valve body shall be marked with cast or stamped lettering giving the following information :

i. Class of Valve.

ii. The Size of Valve.

iii. The Manufacturer's name or Trademarks.

I. Preparation for Dispatch

After testing, each valve shall be drained, cleaned and closed. Valves shall be prepared for dispatch in such a way to prevent the possibility of damage to inside or outside parts during transit.

J. Protection

Valves shall be protected, externally by epoxy coating of thickness not less than 150 microns, and suitable for water temperature 50^{o}C and ambient temperature 85^{o}C and all parts in contact with water shall be coated by rubber or epoxy coating.

803.12 MANHOLE COVERS

The manhole covers and frames shall be made of Ductile Iron medium or heavy duty unless otherwise shown in the Contract Documents, they shall be manufactured to BS EN124 and be ventilated. They shall be of sound manufacture and free from projections and voids or other defects and coated to BS 3416. Minimum thickness 250 microns.. Two sets of lifting keys shall be supplied with each removable cover.

The top shall be marked with the letters E&W and/or any text insertion requested by the MEW.

803.13 SURFACE BOXES

Surface boxes for valves shall comply with BS 5834 type C with clear opening as stated on the Drawings. Frames and lids are to be cast iron to BS EN 1561, studs, bolts, nuts and hinge pins are to be mild steel M12, chains are to be mild steel or wrought iron.

Boxes shall be of square shape with clear opening of 22.5 x 22.5 cm unless stated otherwise stated on the Drawings. The cover and frame shall be protected with 2 coats of black epoxy paint over a primer.

803.14 STEP-IRONS AND LADDERS

Step-irons shall be to BS EN 13101:PT1. If the chamber height is more than 3m, ladders shall be provided instead of step-irons. Step-irons shall be of stainless steel complying with the requirements of BS EN 10088.

Ladders for manhole chambers shall be of stainless steel complying with the requirements of BS EN 10088, and to the dimensions and configuration shown on the Drawings,"

803.15 MEASUREMENT AND PAYMENT

803.15.1 Basis of Measurement and Payment

A. Supply of Pipes, fittings and joints (By The Contractor)

Measurement for pipes supply shall be by meter, for each type and diameter separately. Measurement for fittings supply shall be by number for each size and type. Joints supply shall not be measured for direct payment but shall be considered as subsidiary Works, the costs of which shall be deemed to be included in the Contract prices for pipes.

The rates for supplying pipes and fittings shall include for but not be limited to:

- Supply of pipes, fittings, coupling, polyethylene encasement, protection and all appropriate specials and jointing materials.
- Transportation and hauling to Site, loading, unloading and storage.
- Inspection and testing.
- All ancillary materials.

B. Supply of Valves, Hydrants and Flow Meters (By The Contractor)

Measurement for valves, hydrants and flow meters supply shall be by number for each size and type.

The rates for supplying valves, hydrants and flow meters shall include for but not be limited to:

- Supply of valves, hydrants and flow meters and all related protection, specials and jointing materials.

- Transportation and hauling to Site, loading, unloading and storage.
- Inspection and testing.
- All ancillary materials.

C. Supply of Surface Boxes (By The Contractor)

Measurement for surface boxes supply shall be by number.

The rates for supplying a surface box shall include for but not be limited to:

- Supply of cover & frame and all related protection, specials and installation materials.
- Transportation and hauling to Site, loading, unloading and storage.
- Inspection, testing and all ancillary items.

D. Supply of Valve Chamber Furniture (By The Contractor)

Measurement for valve chamber furniture supply shall be by number for each valve chamber type.

The rates for supplying valve chamber furniture shall include for but not be limited to:

- Supply of manhole covers & frame and all related protection, specials and installation materials.
- Supply of step irons and/or ladders and other items shown on the Drawings including all related protection, specials and installation materials.
- Supply of any furniture required for the proper construction and operation of the chamber.
- Transportation and hauling to Site, loading, unloading and storage.
- Inspection, testing and all ancillary items.

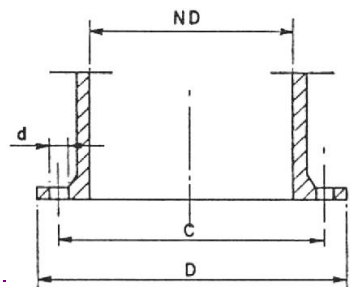
803.15.2 Items in the Bill of Quantities

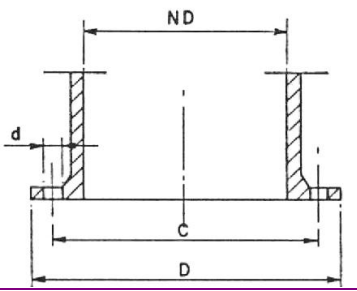
PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
803.1	Pipe (type and diameter)	m
803.2	Fittings (type and size)	nr
803.3	Valve (type and size)	nr
803.4	Hydrant (type)	nr
803.5	Flow Meter (type and size)	nr
803.6	Surface Box (size)	nr
803.7	Valve Chamber Furniture (per type of valve)	nr

804 - FLANGES – DIMENSION REQUIREMENTS

804.01 GENERAL REQUIREMENTS

Flanges shall be to the following dimensions:





ND mm)	D (mm)	C (mm)	Holes		Bolts
			d (mm)	number	(in)
80	200	160	18	8	M16
100	220	180	22	8	M16
150	285	240	22	8	M20
200	340	295	22	8	M20
250	395	350	22	12	M20
300	445	400	22	12	M20
350	505	460	22	16	M20
400	565	515	26	16	M24
450	615	565	26	20	M24
500	670	620	26	20	M24
600	895	725	29.5	20	M27
800	1015	950	32.5	24	M30
1000	1230	1160	35.5	28	M33
1200	1455	1380	39	32	M35

Note : Drilling Unless otherwise shown in the Contract Documents, flanges shall be in accordance with ISO 7005-2.

Table 804.01 – Dimension Requirements for Flanges

805 - FACE TO FACE DIMENSIONS FOR VALVES

805.01 REQUIREMENTS

Face to face dimensions for Butterfly and Sluice Valves shall be as follows:

Pipe Size (mm)	Face to Face Dimension (mm)
1200	630
1000	550
800	470
600	800
500	700
400	600
300	500
250	450
200	400
150	350
100	300
80	280
50	250

Table 805.01 – Face to Face Dimensions for Valves

806 - SUBMITTAL SCHEDULES

806.01 GENERAL

The Contractor shall submit completed copies of the Submittal Schedules A to D for Valves, Hydrants, Electro Magnetic Flow Meters and Tests at the Place of manufacture for all materials the Contractor is proposing to supply under the Contract for the approval of the MEW/Engineer.

SECTION 8 MATERIALS FOR WATER WORKS

SUBMITTAL SCHEDULE A

TECHNICAL INFORMATION FOR VALVES

The Contractor is required to complete the following table and state clearly to which standard specification the different parts are manufactured.

Valves	Material	Standard Specification BS or Equivalent
Sluice Valves		
Body		
Bonnet		
Wedge		
Seat Rings		
Stem		
Gland		
Bolts		
Butterfly Valves		
Body		
Disc		
Shaft		
Seat Ring		
Gears		
Sealing Ring		
Bearing Bushes		
O-ring Seas		
End Cover		
Air Valves		
Body		
Cover		
Bonnet		
Valve Spindle		
Seat Ring		
Seating		
Floating Ball		

SECTION 8 MATERIALS FOR WATER WORKS
SUBMITTAL SCHEDULE B
ELECTRO MAGNETIC FLOW METER

Manufacturer's Name and Address.....

Type of Tube.....

Size of Tube .....

Max Permissible water temp °C.....

Min Permissible water temp °C.....

Max Flow in m^3 per minute.....

Average Flow in m^3 per minute .....

Highest working pressure in kg/cm^2 .....

Lowest working pressure in kg/cm^2.....

Start to register at about m^3 per minute .....

Reset Automatically to zero at million m^3. .....

Accuracy percentage .....

SECTION 8 MATERIALS FOR WATER WORKS

SUBMITTAL SCHEDULE C

VALVES

If the Contractor offers materials, which do not accord to BS or other standards indicated in the Specifications he shall give a complete analysis for the materials from which different parts are manufactured.

All information shall be in English language.

The Contractor must state clearly in his submittal the following information.

1. For Sluice Valves

   Working Pressure .....

   Water test pressure for tightness for strength .....

2. Butterfly Valves

   Working Pressure.....

   Test pressure at Gate Open .....

   Gate Closed .....

3. Hydrants

   Working Pressure .....

   Test pressure at Gate Open .....

   Gate Closed .....

   Signature of Contractor.....

   Date.....

SECTION 8 MATERIALS FOR WATER WORKS

SUBMITTAL SCHEDULE D

FACTORY TESTS

The Contractor shall state hereunder details of the tests he proposes to carry out at the place of manufacture on all pipes, couplings, valves, fittings and hydrants.

Signature of Contractor:.....

SECTION 9 : WATER PIPELINE CONSTRUCTION

900 - GENERAL

900.01 SCOPE

This Section describes the requirements for the construction of water pipelines and is to be read in conjunction with the Drawings and with the other Contract Documents.

The water mains shall be laid and maintained to the required lines and grades with fittings, valves and hydrants etc., at the required locations. The works shall also include for the connection of the new pipelines to the existing mains, as shown on the Drawings .

A land survey and site investigations of the route of each pipeline shall form part of the required works if any; in addition to provision of design engineers to adjust the Drawings as necessary in accordance with the information gathered, and the production of construction drawings including all details for connections.

900.01.1 Standards and Codes

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

BS

BS EN 124	Gully tops and manhole tops for vehicular and pedestrian areas
BS 750	Specification for underground fire hydrants and surface box frames and covers
BS EN 1917	Concrete manholes and inspection chambers, unreinforced, steel fibre and reinforced
BS 3416	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 5911 Part3	Specification for unreinforced and reinforced concrete manholes and soakaways

IEC

IEC 60227-1	Polyvinyl Chloride Insulated Cables of Rated Voltages Up to and Including 450/750 Volts
IEC 60811	Common Test Methods for Insulating and Sheathing Materials of Electrical Cables and Optical Cables

AWWA

C 502	Dry-Barrel Fire Hydrants
C 651	American National Standard for Disinfecting Water Mains

Telephone Industry Standards BPO (British Post Office)

CW 128T

Tables 2 & 3 Cable Protection Sheaths, Insulation and Colour Codes

BPO Table: Armouring Wire Diameters

900.01.2 Inspection and Investigation of Site

The Tenderers shall inspect and examine the Site and its surroundings and shall satisfy themselves before submitting their tender as to the nature of the ground and subsoil, the quantities and nature of the work and materials necessary for the completion of works.

The extent, size, position and type of any existing services shown on the Drawings have been based on information extracted from the records of the various authorities and must be regarded as approximate only. The Contractor shall make his own investigations and inquires of the various Government Ministries and other authorities to ascertain exact positions, sizes, and numbers and detail of all abstract in order to prepare construction drawings.

The rates given in the Bills of Quantities and the Schedule of Rates shall include for all costs involved in negotiating obstacles and no claim will be considered for any additional expense the Contractor may incur on account of obstacles of whatever nature including these needing deeper excavation and any necessary supports.

Any excavation needed to determine the exact location and level of obstacles shall be carried out by the contractor. The Tenderers shall obtain for themselves all further information required as to risks, contingencies and other circumstances which may influence or affect execution of the works and include the costs thereof in their tender

900.01.3 Tender Drawings

TheTender Drawings together with the Specification form part of the Contract. Where figures are shown on the Drawings, they shall take precedence over scaled distance and dimensions.

The Tender Drawings are intended to provide the Tenderers which sufficient information for them to prepare their tenders. They are not guaranteed to be accurate or correct and the Contractor should carefully check all dimensions, notes and other information used.

900.01.4 Definitions

MEW – Minisrty of Electricity and Water

Employer - As defined in the General Conditions of Contract

Engineer - As defined in the General Conditions fo Contract

KFSD - Kuwait Fire Services Directorate

900.02 EXISTING SUBSTRUCTURES AND SERVICES

The Drawings indicate the approximate location of existing substructures and services along the route of the pipeline. The Employer does not guarantee that the locations or depths shown are correct or that all services are shown and the Contractor shall investigate the route of all proposed pipelines to determine the precise location and level of all services and substructures.

900.03 CAUTION IN EXCAVATION

The Contractor shall proceed with caution in the excavation and preparation of trenches so that the exact location of underground structures, both known and unknown, may be determined, and he shall be held responsible for the repair of such structures when broken or otherwise damaged.

The Contractor shall be responsible for locating and protecting all underground structures and lines. The pipeline shall have a minimum clearance of 300 mm from all intersecting pipelines, conduits or other metallic structures, or such additional clearance as may be required by the Owner of the interfering structure. In the case of non-metallic structures a minimum clearance of 500 mm is required. Clearance on one side or the other of any interfering structure will be determined by the MEW/Engineer. In the event that underground pipelines and cables, telegraph or other poles, lighting columns etc. may be affected by the work, the Contractor must notify the MEW/Engineer before work is commenced, and must take all necessary precautions for the protection of the respective pipelines, cables, poles etc. Excavations may not be carried out by machine in the vicinity or existing services without special permission and approval of all the Authorities concerned. When removal, relocation or reconstruction of any poles, cables, pipes or any other services whatsoever is necessary for the pursuit of the Contract, the Contractor shall notify the MEW/Engineer and the appropriate Authority. All work in connection with the removal or re-siting of these or any services shall be carried out by the Contractor or may be carried out by that Authority if the Authority chooses to do so.The Contractor shall, if necessary, give such Authorities all reasonable assistance and access during the undertaking of the work.

Marking points (triangulation points, bench marks and other surveyor’s boundary marks of various kinds) may not be removed from their positions, nor shall work be carried on so near to them that risk of disturbance may arise unless otherwise approved by the MEW/Engineer. Instructions given by the Department of Surveys of the Municipality of Kuwait must be obeyed unconditionally, and the replacing of disturbed or temporarily removed marks etc. must be supervised by the Department of Surveys.

The Contractor is to take all reasonable precautions to avoid damage to any structure owned by other parties. If damage should occur, the Owner of the damaged structure is to be contacted immediately by the Contractor and the repairs are to be made by the Contractor under the direction and to the satisfaction of the Owner, unless otherwise instructed by the MEW/Engineer. The Contractor's rates must include for all costs involved in complying with this Clause.

900.04 SUBSURFACE AND GROUND EXPLORATIONS

The pipeline route shown on the Drawings and the information given thereon concerning obstructions are given for guidance only. The Contractor's rates must allow for possible deviations from the route shown on the Drawings.

The Contractor shall allow in his rates for excavation and backfilling whatever trial holes he deems necessary.

900.05 CONSTRUCTION DRAWINGS

To prepare the construction drawings for the MEW's/ Engineer's approval, the Contractor shall:

1. Modify the plan and profile Drawings to suit the actual conditions along the route of each pipeline.
2. In the event of changes or modifications to pipeline routes, prepare revised plan and profiles drawings to suit these changes or modifications.
3. Check the standard details design for each typical installation and if inadequate for the location shown redesign as necessary.
4. Prepare detailed drawings of all connections showing the arrangement of fittings method of construction, levels, dimensions and other details. Prepare full working drawings and design calculations for any other part of the work not covered by the standard details.
5. Top level of all chamber covers should be shown on the drawings.
6. Where possible, the Contract Drawings shall be used as a basis for the construction drawings.

The construction drawings must be approved before work commences and the Contractor must allow three weeks for the MEW/Engineer to consider any drawing offered for approval. No claim for delay shall be considered if this condition is not fulfilled.

The Contractor shall make any changes in the offered drawings as may be found necessary upon inspection by the MEW/Engineer. The Contractor shall submit four (4) copies of the construction drawings each time they are offered to the MEW/Engineer for approval.

Upon approval of the above drawings, prints, and other details, the same shall become a part of this Contract, provided that the approval of the above drawings, lists, prints, specifications samples or other details shall in no way release the Contractor from the responsibility for the proper fulfillment of the requirement of this Contract. The Contractor shall check all dimensions and quantities on the Drawings furnished by the Employer or by himself and shall notify the MEW/Engineer of all errors or omissions which he may discover as the works proceed. He will not be allowed to take advantage of any errors or omissions in the Drawings, as full instructions will be furnished by the MEW/Engineer should such errors or omissions be discovered and the Contractor shall carry out such instructions as if originally specified.

The Contractor's rates shall include for all of the above..

900.06 DEPTH OF PIPE

All pipes shall be laid to the depths shown on the Drawings and/or Bills of Quantities. Any variation therefrom shall be made only on the order of the MEW/Engineer.

900.07 GRADE

The pipes shall be laid with a minimum gradient of 2 per 1000 (0.2%).

900.08 SETTING-OUT REFERENCE POINTS

The Contractor shall be responsible for erecting and maintaining sufficient and adequate temporary bench marks and sight-rails, etc. to ensure the true and accurate laying and installation of the Works.

Temporary bench marks shall be securely founded and protected, and shall be located within 30 m of the place of work. They shall not be removed until permission to do so has been obtained from the MEW/Engineer.

Sight-rails shall be used in sets of three or more. The use of only two sight-rails on any length of pipe or any grade will not be permitted. The maximum distance between two adjacent sight-rails shall be 25 m. Sight-rails may not be 'boned in' and 'over-boning' will not be permitted. They shall not be removed until permission to do so has been obtained from the MEW/Engineer.

901 - EXCAVATION & PREPARATION OF TRENCHES

901.01 DESCRIPTION

The trench shall be dug in any material so that the pipe can be laid to the alignment and depth required and it shall be excavated only so far in advance of pipelaying as permitted by the MEW/Engineer. The works shall include all necessary clearing and grubbing, bailing, draining, shoring, planking, strutting and supporting the sides of excavation.

901.02 CLEAR AND GRADE THE PIPELINE ROUTE

The Contractor shall include for clearing the route of the pipeline of all surface obstructions, grading the route to provide access for his equipment and personnel, executing all cuttings to remove the high point of rises in terrain and in all respects preparing the route for pipe laying operations, all in accordance with the requirements of good pipeline construction practice.

901.03 WIDTH OF TRENCHES

The width of the trench shall be ample to permit the pipe to be laid and jointed properly and for the backfill to be placed and compacted as specified.

Unless otherwise shown on the Drawings, the width of trenches for pipes (up to 300mm height above the crown of the pipe) shall not exceed the following:

- For pipes not exceeding 65 mm diameter: 300 mm.
- For pipes over 65 mm and not exceeding 600 mm diameter: Nominal diameter + 600 mm.
- For pipes over 600 mm diameter: Nominal diameter + 1000 mm.

Trenches shall be of such extra width, when required, as will permit the convenient placing of timber supports, sheeting and bracing and handling of specials.

Where trenching is across or adjacent to roadways or other services or at points where the ground contours may require extra depth in order to maintain the necessary cover or at any other points where directed by the MEW/Engineer, then the Contractor shall excavate such extra depths as necessary and as directed by the MEW/Engineer.

901.04 JOINT HOLES

Joint holes shall be provided at each joint to permit the joint to be made properly.

901.05 PIPE CLEARANCE IN ROCK

Ledge rock, boulders and large stones shall be removed to provide a clearance of at least 150 mm below and on each side of all pipes, valves and fittings. The specified minimum clearances are the minimum clear distances that will be permitted between any part of the pipe and appurtenances being laid and any part, projection, or point of such rock, boulder or stone.

901.06 EXCAVATION TO GRADE

The Contractor shall not commence excavation of any section of work until a full supply of pipes and fittings is available for that section.

The trench shall be excavated to the depth required so as to provide a uniform and continuous bearing and support for the bottom quadrant of the pipe on solid and undisturbed ground at every point between joint holes, except that it will be permissible to disturb and otherwise damage the finished surface over a maximum length of 500 mm near the middle of each length of pipe by the withdrawal of pipe slings or other lifting tackle. Any part of the bottom of the trench excavated below the specified grade of the trench invert shall be refilled with approved material and thoroughly compacted as directed by the MEW/Engineer. The finished trench invert shall be prepared accurately by means of hand tools.

Abrupt changes in inclination will not be permitted.

The trench invert beneath the centerline of the pipe shall be finished to within 10 mm of a straight line between pipe joints or batter boards, and all tolerances shall be above the specified grade.

In the banks and or approaches to streams or washcrossings, gullies, congested subsurface structures and pipe-line crossings and manholes, the Contractor shall dig the trench to the slope specified by the MEW/Engineer.

In all cases, a minimum clearance of 300 mm from all sub-structures and other lines shall be maintained.

Excavation with battered sides shall not be permitted within 4m of any building or other structure.The Contractor shall allow for executing all cuttings as required, with the sides sloped to stable angles.

Every precaution shall be taken against slips and falls of any material in the excavation, but in the event of any occurring, the Contractor shall at his own expense remove and subsequently backfill the materials that fall.

If through negligence or error of the Contractor, any excavations be taken to a level lower than is shown on the approved Drawings, the Contractor at his own cost, shall backfill the void so formed to the proper level with approved materials in layers not exceeding 100 mm thick which shall be compacted as directed by the MEW/Engineer. The finished trench invert shall be prepared accurately by means of hand tools. If the MEW/Engineer considers that concrete is necessary for this backfilling, then the Contractor shall provide this at his own expense.

In combined trenches where one pipe is at a lower level than an adjacent pipe the following shall be applied:

- The whole trench shall have a depth related to the lower pipe and the thickness of the bedding shall be increased to the upper pipe as necessary.
- The lower pipe shall be backfilled with thoroughly compacted granular material up to a level of 0.30 meters above the higher pipe

901.07 EXCAVATION BELOW GRADE

If so ordered by the MEW/Engineer, the trench shall be excavated to a given depth below the specified grade. Before the pipe is laid, the trench invert shall be made by backfilling in accordance with Clause 208 of Section 2 (Earthwork) of these Specifications to provide a uniform and continuous bearing and support for the pipe at every point between joint holes except that it will be permissible to disturb and otherwise damage the finished surface over a maximum length of 500 mm near the middle of each length of pipe by the withdrawal of pipe sling or other lifting tackle. The finished subgrade shall be prepared accurately by means of hand tools.

901.08 EXCAVATION IN POOR SOIL AND REFILLING TO GRADE

Where the bottom of the trench at trench invert level is found to be unstable, to include ashes, cinders, refuse, vegetable or other organic material, or large pieces or fragments of inorganic material that in the judgement of the MEW/Engineer should be removed, the Contractor shall excavate and remove such unsuitable material to the width and depth ordered by the MEW/Engineer. Before the pipe is laid, the trench invert shall be prepared as specified in Clause 901.07 hereof.

901.09 SPECIAL FOUNDATION IN POOR SOIL

Where the bottom of the trench at subgrade level is found to consist of material that is unsuitable to such a degree that in the opinion of the MEW/Engineer, it cannot be removed and replaced with approved material and compacted in place to support the pipe properly, the Contractor shall construct a foundation for the pipe, consisting of piling, timbers, or other materials, in accordance with plans prepared by the MEW/Engineer.

901.10 SUBGRADE IN ROCK TRENCHES

Where excavation is made in rock or boulders and the clearance specified in Clause 901.05 hereof is provided, the trench invert shall be made as specified in Clause 901.07 hereof before the pipe is laid but rates for excavation shall include for that work.

901.11 SUBGRADE FOR BLOCKING

Blocking will not be permitted.

901.12 ROCK EXCAVATION

Where rock or other hard material exists along the route of the pipe-line, the Contractor shall excavate the trench deeper and wider as specified by the MEW/Engineer.

After excavation, the Contractor shall collect fine sand from the surrounding area and fill the trench with 150 mm of such sand before lowering the pipe. After lowering the pipe into the trench, the Contractor shall cover the pipe with a layer of fine sand, to a height of at least 150 mm over the pipe crown. The sand shall be compacted around the pipe by mechanical means to the satisfaction of the MEW/Engineer. Water flooding will not be permitted. After compaction, material from the spoil bank may be backfilled into the trench.

901.13 BLASTING

Blasting for excavation shall be carried out under thorough and competent supervision, and will be permitted only after securing the permission from the appropriate Authorities and the approval of the MEW/Engineer. Any necessary permits for blasting are to be secured by the Contractor at his own expense. If such permission is refused by the said Authorities for any reason whatsoever, the Contractor shall remove all rock using hand tools at no extra cost to the Employer.

If and when permission is obtained, the Contractor shall be fully responsible for taking all precautions for the protection of persons and property, and for complying without question with the instructions of the appropriate Authorities. The hours of blasting shall be fixed by the MEW/Engineer and the appropriate Authorities. Any damage caused by blasting shall be repaired by the Contractor at his expense. Methods of procedure in blasting and handling and storing the explosives shall conform in all respects to Kuwait law.

Where blasting is found necessary and approval has been granted, then this operation shall be carried out only after occupants of nearby buildings, stores, etc., have been notified by the Contractor sufficiently in advance for them to protect their property. Blasting shall take place in the presence of the MEW/Engineer and the appropriate Authorities or their delegated representative. The Contractor shall blanket the shots in order to prevent damage to underground structures such as cables, conduits and pipelines, springs and other underground water courses and any other existing services. Explosives and detonators shall only be issued as and when required for immediate use and the issue shall be in the charge of a responsible person to be appointed by the Contractor and approved by the MEW/Engineer and the appropriate Authorities. The Contractor shall employ only experienced and trained workmen to supervise, handle and use explosives.

If during blasting operations loose rock is scattered over the Right-of-Way or adjacent property, the Contractor shall immediately clean up such rock to the satisfaction of the MEW/Engineer and the Owner of the land and/or his tenant.

When applying to the appropriate Authorities for permission to use blasting, the Contractor shall submit full details of his proposals including the type of explosive and detonators he would use, the system of ignition and the names and qualifications of the persons who will supervise blasting operations. The Contractor is advised that permission for blasting is not readily given and he should make early and thorough enquiries from the said Authorities in this respect.

Refer to Section 1 (General) of the Specifications for further requirements regarding the use of explosives.

901.14 BRACED AND SHEETED TRENCHES

The Contractor shall supply and fix all timber necessary for the support of the sides of the excavations, for the security of adjacent structures and for every purpose for which it may be required and he shall maintain the same until in the opinion of the MEW/Engineer the work is sufficiently advanced to permit withdrawal of the timber.

The Contractor shall be responsible for any damage caused to roads, mains, cables, pipes, sewers, etc. during the execution of the work. When close sheeting is required, it shall be so driven as to prevent adjacent soil from entering the trench either below or through such sheeting. Where sheeting and bracing are used, the trench width shall be increased in order to maintain the required minimum width between the sheeting.

Sheeting may only be removed after the backfilling has been brought up to such an elevation as to permit its safe removal.

901.15 CARE OF SURFACE MATERIAL FOR REUSE

All surface materials that, in the opinion of the MEW/Engineer, are suitable for reuse in restoring the surface shall be kept separate from general excavation material, as directed by the MEW/Engineer.

901.16 STOCKPILING OF EXCAVATED MATERIAL

During excavation, material suitable for backfilling shall be stockpiled at sufficient distance from the sides of the trench as to avoid overloading and prevent cave in, and in a manner that will not endanger the work and that will avoid obstructing highways, sidewalks and driveways. Hydrants under pressure, valve chamber covers, valve chambers, kerb stop boxes, fire and police call boxes or other utility controls shall be left unobstructed and accessible until the work is completed. Gutters shall be kept clear or other satisfactory provisions made for street drainage and other watercourses shall not be obstructed. All excavated material not required, or unsuitable for backfilling shall be removed and carted away to an approved dumping area.

901.17 TRENCHING BY HAND OR MACHINE

901.17.1 Hand Excavation

Along those sections where existing services (cables, water mains, sewers etc.) cross the line of the trench, excavation must be by hand.

901.17.2 Machine Excavation

Machine excavation may be used on obtaining the prior approval of the MEW/Engineer. Excavation by machine must not be deeper than 150 mm above the bottom of the trench, unless the MEW/Engineer directs otherwise. The remaining excavation shall be by hand. The Contractor will be held responsible for making good all damage to road surfaces and land caused by the use of mechanical excavators.

901.18 BARRICADES, GUARDS AND SAFETY PROVISIONS

To protect persons from injury and to avoid property damage, adequate barricades, constructions signs, torches, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for traffic to use the highway. All materials, stockpiles, equipment and pipes that may serve as obstructions to traffic shall be enclosed by fences or barricades and shall be protected by proper lights when the visibility is poor. Safety rules and regulations of local Authorities shall be observed especially those issued by the Services Sub-Committee and the Police and those incorporated in Section 18 (Maintenance and Protection of Traffic) of these Specifications.

901.19 MAINTENANCE AND PROTECTION OF TRAFFIC

The Contractor is to comply with all regulations given in the Contract Documents.

901.20 PROTECTION OF EXISTING STRUCTURES

The Contractor shall be responsible for the care and protection of all existing sewer pipes, water pipes, gas and oil mains, culverts or other service or other facilities and structures which may be encountered in or near the area

of this work. Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of the work shall be furnished by the Contractor at his expense and under the direction of the MEW/Engineer. Any structures that have been disturbed shall be restored upon completion of the work.

In the event of any damage to the existing facilities and services during the progress of the work and of the failure of the Contractor to exercise the proper precautions, the Contractor will be held liable for the cost of repairs and protection to all such facilities and services.

901.21 PROTECTION OF PROPERTY AND SURFACE STRUCTURES

Trees, shrubbery, fencing, poles and all other property and surface structures shall be protected unless their removal is shown on the Drawings or authorised by the MEW/Engineer.

Where it is necessary to cut roots and tree branches, such cutting shall be done under the supervision and direction of the MEW/Engineer after obtaining permission from the appropriate Authority in Kuwait. Any such trees, shrubs, hedges, etc. damaged or removed during the Contract shall be paid for by the Contractor.

901.22 INTERRUPTION OF SERVICE

No valve or other control on the existing system shall be operated for any purpose by the Contractor. The Ministry of Electricity and Water or Kuwait Fire Brigade will operate all valves, hydrants, blow-offs and kerb stops etc. which may be necessary during the course of the Works.

901.23 REPLACEMENT OF EXISTING SEWERS

Wherever it is necessary for the water main to pass underneath an existing sewer or lateral which crosses the line of the trench and such existing pipe is damaged, or a sewer or lateral is broken during construction, the Contractor shall provide cast iron soil pipes or cast iron pressure pipes, couplings and other required material and labour to replace the said sewer or lateral in accordance with the MEW's/Engineer's directions. Before the repairs are covered, they shall be approved by the MEW/Engineer.

901.24 PEDESTRIAN AREAS

Where the trench cuts or crosses any side-walk, pavement or pedestrian area, all paving slabs, etc., shall be carefully removed and stacked ready for reuse. Any breakages, damage or shortage shall be made good at the expense of the Contractor. The Contractor shall provide at his own expense all necessary warnings, signs, lights, barricades and means of access to ensure the safety of the Public.

All paving slabs, titles/blocks, etc., shall be removed, replaced and bedded accordance with the provisions laid down in Section 5 (Concrete Works) of these Specifications.

901.25 DRAINAGE OF TRENCHES

The Contractor shall, at his own expense, pump out all water or sewage which may arise or be brought into excavations or any kind from existing sewers, drains and water-courses or from rainfall or flashstorms and shall, where necessary, thoroughly drain the Works.

The route of the pipeline may pass through certain areas where underground water will be encountered during excavations and the Contractor shall, at his own expense, provide, maintain and work such engines, pumps, pipework, chutes, well points, extractor wells and other things necessary to keep ground or accumulated water at a level below the bottom of the permanent work for such periods as the MEW/Engineer may direct. After raising the water herein referred to, the Contractor shall at once convey it away in such a manner as not to cause any nuisance or injury. All sumps or wells which may be required for the purpose of keeping the Works dry shall be sunk clear thereof and shall be filled in afterwards. It is essential that the discharge of the trench dewatering pumps must be conducted to natural drainage channels, drains, or sewers. No discharge through the water mains will be allowed. When pumping is necessary it shall, when of importance for the performance of the works, or when directed by the MEW/Engineer, be carried on continuously and may not be stopped without permission from the MEW/Engineer.

The Contractor shall ensure that a pipe, when laid, is secured against flotation by backfilling part of the pipe between joints or by some other means and the Contractor shall be alerted at all times to take any action necessary in the event of flooding.

901.26 MEASUREMENT AND PAYMENT

901.26.1 Basis of Measurement and Payment

A. Excavation in Trench

Measurement for pipe trenches shall be by metre run for each pipe diameter and for each one metre depth stage except for trenches across roadways which shall be at any depth. Measurement shall be made between two fixed points and the depth for the length between the fixed points shall be determined as the average of the depth at the two fixed points. The depth shall be measured from existing ground level, finished ground level or finished subgrade level, whichever is the lowest, to trench invert level. Fixed points shall be chambers of any type, 'T' or 'Y' branch connections, tapers, blank ends and points of connection to existing lines. The length between fixed points shall be measured up to the outer face of chamber walls, from the point of intersection of pipe centrelines at 'T' and 'Y' branch connections, to the centre of tapers, to the end of the pipework and/or fitting at blank ends (thrust-blocks being measured separately) and to the limit of new pipework at connections to existing lines (excavation beyond for the purpose of making the connection being included in the rates for the work).

In the case where a pipe is (I) partly in fill and partly in original ground or (II) totally above original ground level and is enclosed in fill, the measurement for depth shall be by the lesser of dimensions (i) and (ii) as calculated below.

Dimension (i) – The depth between finished ground level or finished subgrade level, whichever is lower, and the pipe invert level.

Dimension (ii) – The outer diameter of the pipe plus 1000 mm.

Where trenches are to be excavated across existing roads or pavements which are to be re-opened to traffic on completion of the construction work specified within, the depth of such trench excavation shall be calculated from the level of the top of the existing road or pavement to the trench invert level.

Payment for excavation in all types of soil shall be at the rate in the Bills of Quantities, which rate shall include for all temporary works, dewatering, bracing, sheeting, testing, any granular bedding and surrounding to pipework, backfilling, compaction and the use of approved surplus excavated material for filling (including compaction) in other areas of the site, for the disposal of surplus excavated material and/or unsuitable material as specified and for all other items necessary to complete the Works.

In locations where a pavement is to be re-opened to traffic (either temporarily or permanently) on completion of the construction work specified herein, removal and reinstatement of existing pavement courses, precast concrete tiles or blocks and street furniture shall be executed in accordance with Clause 1701 of Section 17 (Utilities Structures) of these Specifications.

Measurement and payment for such removal and reinstatement shall be in accordance with Clause 1701 of Section 17 (Utilities Structures) of these Specifications and payment shall be made under Section 9 of the Bills of Quantities.

In locations where a pavement is not to be re-opened to traffic (and for permanent removal of temporarily reinstated works); measurement for removal of existing pavement, precast concrete tiles or blocks and street furniture shall be according to Clause 207.08 of Section 2 (Earthworks) of these Specifications, and payment shall be made under Section 2 of the Bills of Quantities.

B. Unsuitable Material Below Trench Bottom

Measurement of excavation of unsuitable material below the required trench invert shall be by metre cube.

The trench width for measurement purposes shall be the minimum trench width at the bottom of the trench as shown on the Drawings or as described herein with no allowance for working space.

Payment shall be at the rate inserted in the Bills of Quantities and shall include for excavation, loading, carting away and dumping at approved dumping areas or deposition on Site all as directed or approved by the MEW/Engineer. The rate shall also include for backfilling with approved material as specified.

C. Rock Excavation

Measurement for rock excavation, as defined in Clause 203.05.4, of Section 2 (Earthworks) of these Specifications shall be by the metre cube as an extra over item to the main excavation measure. The volume shall be determined on the basis of the minimum trench widths at the bottom of the trench as shown on the Drawings or as described herein for the particular pipe diameter and depth of rock strata.

Payment shall be at the rate in the Bills of Quantities, which rate shall include for the extra over cost of rock excavation, removal, hauling to approved dumping areas or incorporation in the Works as approved by the MEW/Engineer. Payment shall also include for the supply and spreading of the sand bedding as specified.

901.26.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
901.1	Trench Excavation (pipe diameter/depth stages)	m
901.2	Trench Excavation Across Roadways (pipe diameter)	m
901.3	Excavation of Unsuitable Material (below the required trench invert)	cu.m.
901.4	Extra Over for Rock Excavation (in pipe trenches)	cu.m.

902 – PIPEWORK, VALVES AND FITTINGS

902.01 LAYING OF PIPES

902.01.1 General

The Contractor shall undertake to perform all work necessary to install the pipeline and ancillary works in strict accordance with these Specification.

902.01.2 Handling of Materials at Site of Works

In distributing the material at the Site of the Works, each piece shall be unloaded opposite or near the place where it is to be laid in the trench.

The Contractor shall keep the pipe and appurtenances clean during the progress of the work. Dirt, rocks, or other foreign material shall be removed from the interior of the pipe before installation. All openings in the pipeline shall be plugged water-tight with standard cast iron test plug or an expandable type of sewer plug at the end of each day's operations or whenever the workmen are to be absent from the work area. The use of burlap, wood or other similar temporary plugs will not be permitted. All surface or ground water shall be removed from the trench.

902.01.3 Inspection Before Installation

All pipes, valves and fittings shall be carefully inspected and examined for cracks and other defects while suspended above the trench immediately before installation in final position.

Material found to be defective or damaged shall be rejected and removed from the work. Where a portion of the length of pipe is damaged, the damaged part shall be cut off in an approved manner and discarded and the remaining sound portion may be used. The failure of or damage to any material will be deemed to have been caused by the Contractor's negligence in handling and must be replaced by new such materials or repaired as the MEW/Engineer decides without cost to the Employer. Any material provided by the MEW/Employer which is lost or damaged and replaced by the MEW/Employer will be charged for as set out under Clause 801.01 of Section 8 (Materials For Water Works) of these Specifications.

902.01.4 Lowering into Trench

Proper implements, tools and facilities satisfactory to the MEW/Engineer shall be provided and used by the Contractor for the safe and convenient performance of the Works. All pipes, fittings and valves shall be carefully lowered into the trench piece by piece by means of a derrick, ropes or other suitable tools or equipment in such a manner as to prevent damage to water-main material and protective coatings and linings. Under no circumstances shall water-main material be dropped or dumped into the trench.

If damage occurs to any pipe, fitting, valve or water-main accessory in handling, the damage shall be immediately brought to the MEW's/Engineer's attention. The MEW/Engineer will determine if the item can be repaired and incorporated in the Works or if it is to be rejected. The Contractor shall stand the expenses of repairing or replacing same.

902.01.5 Cleaning of Pipes and Fittings

All lumps, blisters and excess coating shall be removed from the socket and spigot ends of each pipe forming the joint and from the outside of the spigot. The inside of the socket shall be wire brushed and wiped clean and dry and be free from oil and grease before the pipe is laid.

902.01.6 Laying of Pipes

Every precaution shall be taken to prevent foreign material from entering a pipe whilst it is being placed in the line. If the pipelaying crew cannot put any pipe into the trench and in place without debris getting into it, the MEW/Engineer may require that before lowering the pipe into the trench, a heavy tightly woven canvas bag of suitable size shall be placed over each end and left there until the connection is to be made to the adjacent pipe. During laying operations, no debris, tools, clothing or other material shall be placed in the pipe.

As each length of pipe is placed in the trench, the spigot end shall be centred in the socket and the pipe jointed and brought to the correct line and grade. The pipe shall be secured in place with approved backfill material tamped under it except at the joints. Precautions shall be taken to prevent debris from entering the joint space.

All pipe lines must be inspected and approved by the MEW/Engineer before they are covered over.

902.01.7 Cutting Pipes

The cutting of pipe for inserting valves, fittings or closure pieces shall be done in a neat workmanlike manner without damage to the pipe or the protective wrapping and coating and so as to leave a smooth end at right angles to the axis of the pipe. The method of and equipment for cutting shall be approved by the MEW/Engineer.

The Contractor shall, at his own expense, clean up and level the ends of the cut parts to facilitate the insertion of the pipes.

The Contractor shall, if so directed by the MEW/Engineer, return to the MEW's/Employer's store from which they were provided all off-cut pieces from the Site on completion of the Works.

902.01.8 Direction of Joints

If and when laying pipes with spigot and socket joints, such pipes shall be laid with sockets facing in the direction of laying, unless directed otherwise by the MEW/Engineer. Where pipe is laid to a grade of 10% or greater the laying shall start at the bottom and shall proceed upwards with the socket of the pipe upgrade.

902.01.9 Deflection at Joints

When pipes are laid in curves, the pipe may not be deflected until the joint has been made. Maximum deflections shall be 2/3 of the value specified by the manufacturer and as approved by the MEW/Engineer.

902.01.10 Assembly of Ductile Iron Pipes and Fittings

The following are recommendations for the assembly of the automatic and mechanical joints which shall be followed by the Contractor under the direction of the MEW/Engineer.

A. Assembly of the Automatic Joint

i. Carefully clean the interior of the socket with a metal brush and rag, paying particular attention to the recess for the joint ring. Also, clean the spigot end of the pipe to be assembled and joint ring.

ii. Coat the recess for the joint ring with the lubricating paste.

iii. Place the joint ring into its recess with the lips towards the bottom of the socket. Check that the joint ring is correctly seated all the way round.

iv. Spread lubricating paste over the exposed surface of the joint ring and the pipe spigot.

v. Make a mark on the barrel at a distance from the spigot end equal to the depth of the socket less 10 mm (3/8 in).

vi. Enter the spigot end of this pipe into the socket of the other.

vii. Centre the spigot inside the socket and maintain the pipe in this position by supporting it on two piles of tamped soil, or better still gravel.

viii. Push the spigot into the socket, checking the alignment of the two pipes, until the mark made on the pipe to be assembled is flush with the face of the socket. Do not enter the spigot any further; this is to avoid metal to metal contact between the pipes and so ensure the adaptability of the joint to pipeline movements. This operation shall be carried out with the aid of a special jack such as a "Tirfor super T.35 cable clamp, sling and hook" (as manufactured by Societe des Founderies de Pont-A-Mousson or equivalent).

ix. Check that the joint ring is still correctly located in its recess by passing the end of a short rule through the annular gap between the spigot and socket to locate the edge of the joint ring. The rule should measure the same depth at all points around the joint ring.

x. Immediately after making the joint, ram stone-free backfilling under the pipe which has just been laid in order to keep it centred in the socket.

B. Assembly of the Mechanical Joint

i. Clean the spigot end of the pipe or fitting with a brush and also the socket of the pipe or fitting to which it is to be assembled.

ii. Slide the gland over the spigot end, followed by the joint ring arranged so that its tip faces towards the socket.

iii. Introduce the spigot end, together with the gland and joint ring, into the socket to its full depth and check the assembly for alignment, then withdraw the spigot end about 10 mm (3/8 in.). This clearance between the end of the spigot and the bottom of the socket allows for free expansion of both components.

iv. Slide the joint ring along the spigot and engage it in its recess, then slide the gland along into contact with the joint ring.

v. Put the bolts into the gland holes and screw the nuts on by hand until they meet the gland. Check that the gland is positioned correctly, then tighten the nuts with a torque spanner gradually and in the correct order.

vi. After the hydraulic test, check the tightness of the bolts and if necessary retighten them.

902.01.11 Installation of the Polyethylene Sleeves

Cut polyethylene as specified under Clause 803.05 of Section 8 (Materials For Waterworks) of these Specifications to a length of approximately 600 mm longer than that of the pipe section. Slip the sleeve around the pipe, centering it to provide a 300 mm overlap on each adjacent pipe section, and bunching it accordion-fashion lengthwise until it clears the pipe end.

Lower the pipe into the trench and make up the pipe joint with the preceding section of pipe. A shallow bell hole must be made at joints to facilitate installation of the polyethylene sleeve.

After assembling the pipe joint, make the overlap of the polyethylene sleeve. Pull the bunched polyethylene from the preceding length of pipe, slip it over the end of the new length of pipe and secure in place. Then slip the end of the polyethylene from the new pipe section over the end of the first wrap until it overlaps the joint at the end of the preceding length of pipe. Secure the overlap in place by using adhesive tape. Take up the slack width to make a snug, but not tight fit along the barrel of the pipe, securing the fold at quarter points.

A. Pipe-Shaped Appurtenances

Cover bends, reducers, offsets and other pipe-shaped appurtenances with polyethylene in the same manner as the pipe.

B. Odd-Shaped Appurtenances

When valves, tees, crosses, and other odd-shaped pieces cannot be wrapped practically in a tube, wrap with a flat sheet or split length of polyethylene tube by passing the sheet under the appurtenance and bringing it up around the body. Make seams by bringing the edges together, folding over twice, and together, folding over twice, and taping down. Handle width and overlaps at joints as described in (a). Tape the polyethylene securely in place at valve stem and other penetrations.

C. Opening in Encasement

Provide openings for branches, service taps, blow-offs, air valves and similar appurtenances by making an X-shaped cut in the polyethylene and temporarily folding back the firm. After the appurtenance is installed, tape the slack securely to the appurtenance and repair the cut, as well as any other damaged areas in the polyethylene, with tape.

D. Junctions between Wrapped and Unwrapped Pipe

Where a polyethylene-wrapped pipe joins an adjacent pipe that is not wrapped, extend the polyethylene wrap to cover the adjacent pipe for a distance of at least 600 mm. Secure the end with circumferential turns of tape.

E. Backfill for Polyethylene-Wrapped Pipe

Use the same backfill material as that specified for pipe without polyethylene wrapping, exercising care to prevent damage to the polyethylene wrapping when placing backfill. Backfill material shall be free from cinders, refuse, boulders, rocks, stones or other material that could damage the polyethylene.

F. Exposure to Sunlight

Prolonged exposure to sunlight will eventually deteriorate polyethylene film. Therefore, such exposure prior to backfilling the wrapped pipe should not be more than 24 hours.

902.02 SETTING OF VALVES, FITTINGS, HYDRANTS

902.02.1 General Requirements

Valves shall be the same size as the main in which they are to be installed.

Valves should be as specified in Clause 803.08 of Section 8 (Materials For Waterworks) of these Sepcifications.

Hydrants shall be the screw-down underground type in accordance with BS 750 at residential areas and dry barrel, post type to AWWA C502 at remaining areas especially commercial areas and Highways/Motorways, Hydrants shoud be suitable for the actual working pressure (minimum 16 bars).

Valve fittings, hydrants, etc., shall have joints according to the pipeline into which they are to be installed. All these joints shall be made in accordance with the requirements of the appropriate Clauses of these Specifications. All valves and fittings shall be handled and supported during installation in a safe workmanlike manner avoiding damage to the valve or fitting, adjoining pipes and all protective coatings.

Proper care and thorough inspection shall be practiced by the Contractor during the laying of water mains in order to avoid small stones, pieces of concrete, particles of metal, or other foreign material gaining access to the mains and obstructing operation of the valves and water meters.

After installation of the valves and with the working pressure in the main, the valves shall be opened and closed several times and checked to ensure that each valve is in good condition. Particles which have settled in the valves shall be removed by the Contractor.

The Contractor shall at his own expense repair and make good any defects or faults with the valves and hydrants.

902.02.2 Valves and Fittings

All valves and fittings shall be installed at the various positions indicated on the Drawings or as may be directed by the MEW/Engineer.

902.02.3 Valve Chambers

All valves and underground hydrants shall be located in valve chambers. The particular type of chamber is indicated for each valve and construction details of each chamber are given on the Drawings. The valves and hydrants shall be supported in the chambers by concrete plinths on the floor. The extension spindles shall be supported by brackets fixed to the chamber wall. All chambers shall be constructed strictly in accordance with the Drawings, unless otherwise directed by the MEW/Engineer. Adequate access holes and manhole covers shall be provided to permit the easy installation and removal of the valves for maintenance etc. The chambers shall be made watertight and the Contractor shall supply and install waterbars if necessary or if so instructed by the MEW/Engineer at no extra cost to the Employer.

Cast iron surface boxes as specified in Clause 803.13 of Section 8 (Materials For Waterworks) of these Specifications shall be supplied and installed for the extension spindle of each valve. Extension spindles with accessories shall be supplied and fixed to the roof slab by the Contractor as shown on the Drawings.

902.02.4 Manhole Covers

Manhole covers and frames shall be as specified in Clause 803.12 of Section 8 (Materials For Waterworks) of these Specifications. Samples shall be to the approval of the MEW/Engineer.

All covers and frames shall be painted with an approved bituminous compound before installation.

Frames shall be accurately set to level and bedded in cement mortar. Holes for lifting hooks shall be carefully protected and filled with an oily rag after installation to prevent the ingress of foreign matter.

902.03 DRAINAGE OF MAINS

Mains shall be drained through drainage branches or washouts. Drainage branches, washouts, air vents and appurtenances shall be provided with valves and shall be located and installed as shown on the Drawings.

Drainage branches or washouts shall not be connected to any sewer, submerged in any stream, or be installed in any other manner that could permit back siphonage into the distribution system.

902.04 DEAD ENDS

All dead ends on new mains shall be closed with plugs or caps and such dead ends shall be equipped with suitable washout facilities.

902.05 HYDRANTS

902.05.1 Location

Hydrants shall be located as shown on the Drawings or as directed by the MEW/Engineer/KFSD so as to provide complete accessibility and minimise the possibility of damage from vehicle or injury to pedestrians.

The location of underground hydrants shall be marked by a sign board as detailed in Clause 902.05.2 herein.

902.05.2 Sign Boards

The Contractor shall supply and erect a sign board at each underground fire hydrant as specified on the Drawings.

An indicator plate manufactured of aluminium or steel according to the MEW's/Engineer's/KFB's directions and indicating the distance to the valve shall be fixed to the sign board. Arabic letters and numerals are to be used.

902.06 PAINTING AND COATING

The Contractor shall provide materials, equipment and personnel to touch-up or repair damage coating of valves, fittings, flanges, connections and all metal parts inside the valve chambers to the approval of the MEW/Engineer.

The rates for fixing of fittings and valves shall include for the supply of all materials needed and for touch-up or repairing damaged.

902.07 MEASUREMENT AND PAYMENT

902.07.1 Basis of Measurement and Payment

A. Pipelaying

Measurement for pipelaying shall be by metre run, for each diameter separately, at any depth, for the effective net length laid including lengths of fittings, but excluding lengths of valves. Fittings installation shall not be measured for direct payment but shall be considered as subsidiary Works, the costs of which shall be deemed to be included in the Contract prices for pipelaying. At branches in pipelines the pipe length for each branch shall be measured from the point where the pipe centrelines intersect. The length of taper fittings shall be included in the pipelaying measure.

The rates for laying pipes and fittings shall include for but not be limited to:

a. All loading, transporting, white-washing where necessary, handling, stringing, lowering, laying in trench, culvert or chamber to line and level, jointing the pipes and/or fittings together in the specified manner, including for preparation of the pipe ends as specified, and for cutting at chambers and for chamfering the ends where necessary.

b. All cutting of pipes where required for short lengths and for joints, whether shown on the Drawings or not.

c. Hydrostatic test of the pipelines as specified, including for the supply of all necessary materials, equipment, etc. and the cost of supplying water.

d. Preparation and submission of construction drawings.

e. Wrapping with polyethylene sleeves as specified.

f. Any other operations, work and all things necessary to ensure that the completed pipelines meet the requirements of the Specifications, and to the satisfaction of the MEW/Engineer.

B. Installation of Valves and Hydrants

Measurement for valves and hydrants shall be per unit fixed in place for each size and type.

The rates for installation of valves and hydrants shall include for but not be limited to:

a. Fixing of all valves and hydrants complete with the required gaskets, nuts, bolts, washers, by pass connections, and jointing to the line flanges, testing, cleaning and adjusting as necessary.

b. The provision and application of touch-up or repair to damaged protective coating and for the provision and construction of Class K250 mass concrete in supports and plinths inside the chambers.

c. The supply and fixing of extension operating rods up to the roof complete with clamps and other accessories.

d. Any other work, operations, materials, and all things necessary to ensure that the completed work meets the requirements of these Specifications and is to the satisfactions of the MEW/Engineer/KFB.

902.07.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
902.1	Pipe (type and diameter)	m
902.2	Valve (type and size)	nr
902.3	Hydrant (type)	nr

903 - VALVE AND HYDRANT CHAMBERS

903.01 CONCRETE WORKS

Concrete chambers of the type and at the locations shown on the Drawings or as directed by the MEW/Engineer shall be provided. They shall comply with BS EN 1917 and BS 5911 Part 3. Thickness shall be as indicated on the Drawings. Concrete and masonry works shall be as specified in Section 5 (Concrete Works) of these Specifications.

903.02 CONSTRUCTION

903.02.1 Standard Chambers

The Drawings indicate those valves, air valves and washout valves which shall be installed in reinforced concrete chambers of standard design. Underground hydrants shall also be installed in standard concrete chambers whenever possible.

903.02.2 Non-Standard Chambers

Where standard chambers cannot be used, non-standard chambers shall be designed by the Contractor according to site conditions and to the same principles as the design of the standard chambers. The working drawings for the non-standard chambers shall be presented to the MEW/Engineer for approval before construction.

903.03 EXCAVATION AND BACKFILLING

Excavation and backfilling for manholes and chambers shall be in accordance with Clauses 208.01 to 208.07 of Section 2 (Earthworks) of these Specifications.

903.04 CHAMBER FURNITURE

The Contractor shall install all necessary chamber furniture unless otherwise provided for in the Contract Documents. Chamber covers and frames shall be as specified in Clause 803.12 of Section 8 (Materials For Waterworks) and, unless otherwise shown in the Contract Documents, they shall be manufactured to BS EN124 Class D400 and be ventilated. They shall be of sound manufacture and free from projections and voids or other defects and coated to BS 3416. Minimum thickness 250 microns.. Two sets of lifting keys shall be supplied with each removable cover. Covers shall bear the text insertion requested by the MEW.

903.05 PROTECTION OF CHAMBERS

Chambers situated below ground level shall be protected by membrane as specified in Clause 516 of Section 5 (Concrete Works) of these Specifications.

903.06 MEASUREMENT AND PAYMENT

903.06.1 Basis of Measurement and Payment

The approved work shall be measured by the number of each chamber type and size constructed and installed including the installation of frames, grates, covers, step irons, ladders and other furniture as applicable.

No separate measurement or payment shall be made for any concrete works, excavation, backfilling, shoring, sheeting, reinforcing steel, protective membrane, rendering to sides or bottoms of structures, water stops, equipment, forms, tools, furnishing and placing materials, labor, or any other item necessary for the proper completion of the work or for breaking into existing pipes or culverts in order to install new manholes. All such additional items prescribed in this paragraph shall not be measured for direct payment, but shall be considered as

subsidiary Works, the costs of which shall be deemed to be included in the Contract prices for valve and hydrant chambers..

Payment shall be made under Section 9 of the Bills of Quantities and shall include for all labour, plant, additional excavation, installation, fitting, backfilling, forms, tools and materials and everything necessary for the proper execution of the work, including all necessary temporary works, testing and other items and work in connection with the construction.

903.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
903.1	Valve chamber (type and size)	nr
903.2	Hydrant chamber (type and size)	nr

904 - ANCHORAGES

904.01 ANCHORAGES FOR UNDERGROUND HYDRANTS

Underground hydrants will be located in chambers as described elsewhere herein. After jointing each hydrant to the connecting pipework, it shall be securely braced to the chamber wall using metal ties or clamps, as shown on the Drawings or as instructed by the MEW/Engineer.

904.02 ANCHORAGES FOR VALVES AND FITTINGS

All valves, bends, tees, tapers, plugs, caps, etc. shall be braced with concrete thrust blocks or where situated in a chamber, shall be braced against the chamber wall or floor as shown on the Drawings.

All connections to existing mains shall be similarly braced. If additional ties or clamps are required these shall be in accordance with Clause 904.05 hereof.

Thrust blocks for water mains shall be designed by the Contractor if not shown on Drawings, and shall be submitted to the MEW/Engineer for approval. The design should be in accordance with the guidelines given in Clause 904.03 hereof.

904.03 GUIDELINES FOR THE DESIGN OF THRUST BLOCKS

The following guidelines shall be used for the design of thrust blocks:

a. The bearing capacity for soils shall generally vary from min. 120 kN/m^2 to 200 kN/m^2 depending upon the site.

b. The co-efficient of friction between soil and concrete shall be 0.5 for dry soils and 0.25 for wet or submerged soils.

c. The type of concrete shall be K300, for reinforced and unreinforced thrust blocks.

d. The density of concrete shall be 24 kN/m^3 in dry conditions and 14 kN/m^3 in submerged conditions.

e. Angle of internal friction for sand or similar type of soils shall be 30°.

f. Density of soils shall be 18 kN/m^3 for dry conditions and 11 kN/m^3 for submerged conditions. In case of wet conditions the density shall be taken as 20 kN/m^3. In case of the presence of any organic impurity in the soils the case may be considered separately and individually.

g. The design procedure shall be as follows:

   i. The block shall be designed for the test pressure. In the case of a block for more than two lines together, the block shall be designed for the working pressure taken together for all the lines except for one of the lines which should be for test pressure requirements. The single elements, e.g. ‘H’ Beams however shall be designed for the test pressure.

   ii. The block shall be designed with filling up to mid-level of the pipe generally; for underbeds the block shall be designed as above but checked against working conditions, viz, full backfill and working

pressure.

iii. In the case of submerged conditions, the design shall be checked against dry as well as wet conditions, and the worst conditions adopted.

iv. In the case of blocks behind the bends and tees, the filling over the block shall be assumed to act in a trapezoidal form up to ground level with the natural angle of repose of fill material being adopted.

v. For the purpose of evaluating eccentricity the actual passive resistance developed shall be calculated, i.e. for T-F (Thrust developed minus Friction).

vi. The block shall be checked for sliding, overturning, safe bearing and all internal stresses of the concrete.

vii. For overbends, U-bar reinforcement shall follow the curvature of the bend and also touch the same so as to take the direct tension of the thrust in order to avoid the cracking of concrete.

viii. The overall factor of safety for all conditions shall not be less than 1.5.

ix. The eccentricity of the block shall lie within the middle third of the base in order to avoid tension in the concrete.

x. To attain the full passive resistance, the block shall be cast against undisturbed soil.

xi. Precast thrust blocks are not allowed.

904.04 LOCATION OF THRUST BLOCKS

The blocks shall, unless otherwise shown on the Drawings or directed by the MEW/Engineer, be so placed that the pipe and fitting joints will be accessible for repair.

904.05 METAL HARNESS

If so directed by the MEW/Engineer, a metal harness or tie rods or clamps of adequate strength to prevent movement shall be used in conjunction with concrete thrust blocks and or chambers.

Steel rods or clamps shall be galvanised or otherwise rustproofed or shall be painted as specified or directed by the MEW/Engineer.

904.06 MEASUREMENT AND PAYMENT

904.06.1 Basis of Measurement and Payment

Measurement of thrust blocks shall be by the metre cube of concrete and payment at the rates in the Bills of Quantities shall include for all necessary reinforcement, metalwork and for all labour, plant materials and everything necessary for the design and construction of the finished thrust blocks.

904.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
904.1	Concrete in thrust blocks	cu.m

905 - HYDROSTATIC TESTING

905.01 HYDROSTATIC TEST

After completing the installation of a pipeline or a section of the pipeline and before the joints are backfilled hydrostatic tests of the line (branches included) shall be made by the Contractor. Tests shall be carried out in two stages one for the Working Pressure and the other for the Test Pressure. Test pressure shall be as stated in the Contract Documents and shall be 1.5 times the Working Pressure or as shown on the Drawings. A reasonable length of time for the curing of the concrete thrust blocks must be allowed before the test is made. No test shall be made without the prior approval of the MEW/Engineer.

905.02 DURATION OF PRESSURE TEST

After an initial soaking period of six hours, the Working Pressure as applicable shall be applied for a period of 24 hours. During this period the drop or otherwise of the pressure in the line shall be carefully recorded and all joints shall be inspected for evidence of leakage. If the line passes this first stage 'Test' the Test Pressure shall be applied for at least two hours and leakage calculated according to Clause 905.06 herein.

905.03 PROCEDURE

Each section of pipe shall be slowly filled with water and the pressure, corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner approved by the MEW/Engineer. The pressure gauge shall have a satisfactory accuracy within the actual range of pressure. The pump and all necessary apparatus for the test as well as the water required shall be furnished by the Contractor at his own expense.

Except where permitted by the MEW/Engineer, the first test will not be allowed against closed valves but shall be performed against blank flanges or against temporary plugs of stop ends, located in the pipeline outside the valve chamber.

905.04 AIR REMOVAL BEFORE TEST

Before applying the specified test pressure, all air shall be expelled from the pipe. If permanent air vents are not located at all high points, the Contractor shall install suitable cocks at such points so the air can be expelled as the line is filled with water. After all the air has been expelled all cocks shall be closed and the pressure applied. The line shall be filled slowly to prevent water hammer and care shall be taken to remove all of the air.

905.05 EXAMINATION UNDER TEST PRESSURE

All exposed pipes, fittings, valves, hydrants and joints shall be carefully examined during the pressure test. All joints showing leaks shall be rejected until rectified or the pipe material replaced. Any defective pipes or joints, fittings, valves or hydrants discovered as a result of this pressure test shall be repaired or removed and replaced with sound material by the Contractor at his own expense and the test shall be repeated to the satisfaction of the MEW/Engineer.

905.06 LEAKAGE AND PERMISSIBLE LEAKAGE

Leakage is defined as the quantity of water which must be supplied to the laid pipe or any section thereof, to maintain the specified test pressure after the pipe has been filled with water and air expelled. The additional quantity of water pumped into the pipe shall be measured with satisfactory accuracy.

No section of the water main will be accepted until the leakage calculated in litres per km. per 24 hours (for a test pressure of 9.0 kg/cm²) is less than 0.5D, where D is the nominal diameter of the pipe in mm. For a test pressure of 13.5 kg/cm² the corresponding leakage in litres shall be less than 0.75D. The Contractor shall prepare a written report on the results of the leakage test that identifies the specific length of pipe tested, the pressure, the duration of the test, and the amount of leakage. The report shall be signed by the Contractor and the MEW/Engineer or his designated representative.

905.07 TESTING

The Contractor shall provide a sufficient quantity of gauges, pumps, stop ends, pipes and connections and all things necessary and suitable for testing of all pipes as described herein. The Contractor shall also provide all necessary temporary works in connection with the test and shall remove the same on successful completion of the tests. All tests shall be done in the presence of the MEW/Engineer or his designated representative and the results of such tests shall be signed by the MEW/Engineer or his designated representative and handed to the Contractor who shall then prepare the required Test Report.

All equipment, labour and materials necessary for carrying out these tests to the complete satisfaction of the MEW/Engineer shall be provided by the Contractor at his own expense.

Should any test or tests fail the Contractor shall, after repairing and making good any leaks, etc., in accordance with these Specifications, carry out further tests all as above described until such tests meet with the requirements contained herein. All such tests and re-tests shall be at the expense of the Contractor. Water used for testing shall

be supplied by the Ministry of Electricity and Water, if available, at the Contractor's cost. The rates for pipelaying shall include for the cost of such water, which cost shall either be paid for direct to Ministry of Electricity and Water by the Contractor or paid to Ministry of Electricity and Water by the Employer (MPW), at the Ministry of Electricity and Water's option. If Ministry of Electricity and Water elects to charge the cost of the water to the Employer (MPW), then such charge will be treated as a deduction from monies due or to become due from the Employer (MPW) to the Contractor. The rate for purchasing water from Ministry of Electricity and Water will be set by the Ministry of Electricity and Water.

905.08 MEASUREMENT AND PAYMENT

905.08.1 Basis of Measurement and Payment

Payment rate for hydrostatic testing shall be included with the respective rate for pipelaying item in the Bills of Quantities, which includes supply of materials, water, labor, equipment, tools, supplies and other work items necessary for the proper support and completion of the tests as specified above.

906 - BACKFILLING

906.01 GENERAL

Excavations shall be backfilled without unnecessary delay, but not until pipes and construction details have been inspected, tested and approved by the MEW/Engineer. All necessary precautions shall be taken during backfilling to ensure that pipes and construction details are not damaged.

906.02 BACKFILL MATERIAL

All backfill material shall be free from cinders, ashes, refuse, vegetable or organic materials, boulders, rocks, stones or other material which in the opinion of the MEW/Engineer is unsuitable. From the bottom of the trench to at least 300 mm above the crown of the pipe the backfill material shall be such that it will not cause any damage to the pipes or fittings, their protective coatings or polyethylene sleeves.

Initial backfill (up to 300 mm above the top of the pipe) shall be selected fill, sand or other approved material and shall conform to the following:

Standard Sieve Size (mm)	Standard Sieve Designation Mesh	Percent by Weight Passing for Pipes other than uPVC	Percent by Weight Passing for uPVC Pipes
19	¾ in.	100	-
4.76	No. 4	25 – 100	100
1.19	No. 16	10 – 75	25 – 75
0.354	No. 45	5 – 30	10 – 30
0.177	No. 80	3 – 10	3 – 10
0.074	No. 200	0 – 5	0 – 5

Table 906.02.1: Requirements for Initial Backfill - Gradation

The remainder of the trench shall be backfilled with suitable material either from material removed in the course of excavating the trench, or imported from approved borrow pit. In either case the backfill material shall be non-plastic. The percentage by weight passing the No. 200 (0.075 mm) sieve shall not exceed 15 %. The percentage passing the 63 mm shall be 100.

906.03 USE OF EXCAVATED MATERIAL AS BACKFILL

The Contractor may backfill with the excavated material, provided that such material complies with the requirements of Clause 906.02 herein,. If there is a deficiency of backfill material due to rejection of the excavated material for use as backfill, the Contractor shall furnish the required amount of sand or other approved material at his own cost.

906.04 BACKFILLING UNDER PIPE

From the bottom of the trench to the centreline of the pipe all trenches shall be backfilled by hand with approved material and be compacted by tamping. Backfilling material shall be deposited in the trench for its full width on each side of the pipe, fittings and appurtenances simultaneously.

906.05 BACKFILLING OVER PIPE

From the centreline of the pipe, fittings and appurtenances, to a depth of 300mm above the top of the pipe, the trench shall be backfilled and hand compacted in 150mm layers. The Contractor shall use special care in placing this portion of the backfill so as to avoid injuring or moving the pipe. The type of backfill material used shall be as specified in Clause 906.02 herein. The method of placing and consolidation shall be approved by the MEW/Engineer.

906.06 BACKFILLING TO FINISHED GROUND LEVEL

From 300 mm above the pipe to the finished ground level shown on the Drawings or specified herein, the trench shall be backfilled and consolidated by approved hand or mechanical methods in layers not exceeding 150 mm compacted thickness and compacted in accordance with the requirements set out under Clause 605.14 of Section 6 (Stormwater Drainage) of these Specifications.

906.07 BACKFILLING UNDER ROADS PAVEMENT AND PAVED AREAS

Where excavation is made through roads, highways, pavements, kerbs, sidewalks or any paved or pedestrian areas, the trench shall be backfilled and thoroughly compacted. The backfill shall be replaced in the same sequence of layers as it was removed unless otherwise directed by the MEW/Engineer, up to the underside of the sub-base or foundation of the road or highway, etc. Should the MEW/Engineer order that sand or any other approved backfilling material be used in any part of the Works, the Contractor shall furnish such requirements to the appropriate Clauses of the Specifications. Compaction shall be in accordance with the requirements of Clause 203.08 of Section 2 (Earthworks) of these Specifications.

Restoration of asphalt or other types of pavements shall be of materials and thickness to match the existing pavement. Materials and workmanship shall be in accordance with the requirements of Section 4 “Asphalt Works” of this specifications and as directed by the MEW/Engineer.

Restoration of pavement shall be done according to the existing pavement quality and level to ensure that new pavement is matching to provide uniform surface with the existing profile.

Grassed areas shall be restored by spreading, after backfilling, approved fertile soil over affected area. Seeding, fertilizers and water shall be applied until grass is restored to its former condition.

Surface grading shall be carried out to restore all un-surfaced areas and any adjoining areas disturbed to provide a level, smooth surface.

The Contractor shall proceed with restoration of surfaces as soon after completion of other work as is practicable, but in no case more than 10 days after backfilling of trenches and other excavated areas. Restoration shall be completed within 20 days from the start of restoration.

906.08 BACKFILL SAND

All sand used for backfill shall be a natural bank sand, graded from fine to coarse, not lumpy, and free from slag, cinders, ashes, rubbish or any other material that, in the opinion of the MEW/Engineer, is objectionable or deleterious. It shall not contain a total of more than 10% by weight of loam and clay, and all material must be capable of being passed through a 19 mm sieve.

906.09 BACKFILL GRAVEL

Gravel used for backfill shall consist of natural bank gravel having durable particles graded from fine to coarse in a reasonably uniform combination with no boulders or stones larger than 50 mm in size. It shall be free from slag, cinders, ashes, refuse or other deleterious or objectionable materials. It shall not be lumpy.

906.10 REMOVAL OF SURPLUS MATERIAL

The Contractor shall, immediately after excavations have been backfilled and embankments completed, remove and clear away all surplus materials and transport and deposit them at a place directed by the MEW/Engineer.

906.11 EMBANKMENTS, EARTH FILLING AND MADE-UP GROUND

If no suitable material is available for backfilling on the Site the Contractor shall supply it from elsewhere at his own expense.

906.12 SETTLEMENT OF GROUND

Should any subsidence or movement of earth occur at or near to any place where the Contractor has excavated or backfilled at any time during the construction works or maintenance period, the Contractor shall promptly carry out at his own expense and to the satisfaction of the MEW/Engineer, all necessary repairs or reinstatement which may be required as a result of such movements.

906.13 MEASUREMENT AND PAYMENT

906.13.1 Basis of Measurement and Payment

Backfilling of trenches for pipelines, including any material used for this work (whether suitable material resulting from the excavation or borrow material) shall not be measured for direct payment, but shall be deemed to be included in the payment for Trench Excavation.

Restoration of the roadway pavement surface (affected by the trench excavation) to the original conditions, including all types of materials, equipment and workmanship used to complete the restoration works to the MEW's/Engineer's satisfaction shall be paid as per the stipulations of Section 17 (Utilities Structues) of these Specifications.

907 - DISINFECTING & FLUSHING OF FRESH WATER LINES

907.01 GENERAL

Fresh water lines, attached appurtenances and connections if any, shall be disinfected in accordance with the American Water Works Association (AWWA) Specification C651 and then flushed as specified herein.

Brackish water pipes shall be flushed as specified herein. Disinfections of brackish water lines is not required.

907.02 PIPE TO BE CLEANED AND TREATED

It is of utmost importance that every precaution is used to protect pipes, fittings and valves against the entrance of foreign material before the pipe is placed in the new line.

If the Contractor cannot lay the pipe, fittings or valves into the trench and in place without material entering into it, each end shall, on the MEW's/Engineer's instruction and to his satisfaction, be furnished with a heavy tightly woven canvas bag of suitable size before lowering the pipe into the trench. The bag shall be left there until the connection is to be made to the adjacent pipe.

If in the opinion of the MEW/Engineer the pipe contains dirt, the interior of the pipe shall be cleaned and swabbed with a bacterial solution made from the compounds listed in AWWA C651 or other approved equal. A chlorinated lime and water mixture shall not be used.

907.03 POINT OF APPLICATION

The chlorinating agent shall be supplied at the section to be chlorinated and shall be injected through a corporation connection to ensure treatment of the entire system being disinfected.

All required corporation connections necessary for chlorination of the main shall be installed by and at the expense of the Contractor.

907.04 METHOD OF APPLICATION

In addition to the procedure specified in AWWA C651 the use of calcium hypochlorite tablets will also be permitted. The tablets shall be attached by means of an approved adhesive to the inside top of the lengths of pipe as they are being laid. The amount of adhesive shall be limited to the smallest practicable amount applied to one face of the tablets only. Each tablet shall have an average weight of about 5.0 grams and shall contain not less than 70 percent of available chlorine. Adhesive shall be of a type that will not impart taste, odours or detrimental compounds to the water supply.

If the Contractor intends to use calcium hypochlorite tablets, the MEW/Engineer shall be supplied with full details of the method of application and the number of tablets to be used per 100 linear metres. The approved number must not be exceeded by more than 10% and the MEW/Engineer shall in any case be informed.

907.05 HANDLING CHLORINE

Proper care shall be taken to store liquid chlorine or hypochlorite in tightly closed containers where they will not be accessible to children or unauthorised persons. Storage and handling of chlorine shall be according to the manufacturer's instructions and to the MEW's/Engineer's approval.

907.06 RATE OF APPLICATION

Water shall be fed slowly into the pipeline with chlorine applied in amounts to produce at least 5 ppm after 12 hours standing. The dosage must not exceed 10ppm, without the approval of the MEW/Engineer.

907.07 FINAL FLUSHING

Final flushing shall be carried out as directed by the MEW/Engineer.

907.08 REPETITION OF PROCEDURE

If the tests are not satisfactory, the Contractor shall provide additional disinfection as required. If the requirement for additional disinfection is due to any omission, negligence or non-conformance with these Specifications on the part of the Contractor or because of premature wetting of the hypochlorite, or repairs made to the pipeline after its initial filling with water for disinfection, the Contractor shall provide such additional chlorination at his own expense.

The chlorinated water shall be disposed of by the Contractor. The MEW/ Employer will not be responsible for loss or damage resulting from such disposal.

907.09 WATER FOR DISINFECTION AND FLUSHING

Unless it is mentioned clearly in other places in these Specifications that water for flushing and disinfection will be supplied free of charge, the Contractor shall include in his rates for the cost of the fresh water needed for these operations.

The Contractor shall install water metres for recording the quantity of water used for disinfection and flushing the lines.

Payment by the Contractor for water supplied by Ministry of Electricity and Water shall be as described in Clause 905.07 hereof.

907.10 MEASUREMENT AND PAYMENT

907.10.1 Basis of Measurement and Payment

Measurement for disinfection and flushing or flushing only shall be made on completion of the work as a lump sum for the whole of the pipeline and its accessories.

The rates for disinfecting and flushing or flushing only of the water pipeline shall include but not be limited to the supply of all materials including water needed, equipment, cleaning, application of chlorinating agents (for fresh water pipelines) and flushing of the pipelines as specified and as directed by the MEW/Engineer and all necessary temporary connections and any other operation, work and all things necessary to ensure that the completed works meet the requirements of these Specifications and are to the satisfaction of the MEW/Engineer.

907.10.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
907.1	Flushing and disinfecting of fresh water pipeline	LS
907.2	Flushing of brackish water pipeline	LS

908 - CONNECTIONS TO EXISTING MAINS

908.01 REQUIREMENTS

After the complete installation of the pipelines the Contractor shall connect the newly laid line with the existing network in such a way that there is the minimum dislocation in the regular water supply. To ensure this the Contractor shall arrange his work in sections to be agreed with the MEW/Engineer and:

a. Along with the general programme of work, the Contractor shall submit a programme for connection to the existing lines at all the points simultaneously, subject to its approval by the MEW/Engineer.

b. During the execution of the Works, the Contractor shall, with the approval of the MEW/Engineer, mark all the points of 'Joining-in' with the existing lines.

c. Complete in all respects the installation of all the pipelines covered under this Contract before the "Connection Operation" is taken up.

d. Finish the diverted lines as close to the connection points as possible.

e. Have complete arrangements of labour, materials and equipment at all the connection points simultaneously.

f. Start the "Connection Operation" simultaneously at all the points.

g. After the new lines have come into full operation, start with the dismantling, if any, of the existing lines wherever indicated or directed.

908.02 DELAY IN CONNECTION

The Contractor shall note that no claim for any compensation by the Contractor will be entertained if due to any reasons or circumstances, the date or dates of the "Connection Operation" is extended or if the programme is changed by the MEW/Employer. Extension of the Contract Period, if requested by the Contractor, may be studied.

908.03 MEASUREMENT AND PAYMENT

908.03.1 Basis of Measurement and Payment

Rates for connections to the existing pipelines shall include but not be limited to the cutting of roads, removal of pavements, excavation and backfilling in any type of soil, timbering, cutting existing pipes, removing away the cut pieces, repairing all damaged linings and coatings, pumping away any water coming out of the pipelines, and all other water occurring, preparing the pipes for inserting the fittings or the valves (valves measured separately), for testing, for cleaning the site and for any other operation or materials needed for the connection.

Measurement shall be by number for each connection to existing mains made. Separate items shall be measured for each combination of size and type of pipe connected.

908.03.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
908.1	Connection to existing main (size and type)	nr

909 - REMOVAL AND RECOVERY OR DISPOSAL OF EXISTING MAINS, VALVES AND FITTINGS

909.01 GENERAL

The existing mains being replaced generally comprise ductile iron, steel, asbestos cement or cast iron pipes and fittings, and ductile iron, steel or cast iron valves.

Unless otherwise shown on the Drawings or directed by the MEW/Engineer, all ductile iron pipes, fittings, hydrants and valves shall be recovered and shall be thoroughly cleaned. Then the inside of the socket end of pipes and both inside and outside of the fittings and valves shall be further cleaned by sand blasting. Care shall be taken to ensure that no damage is caused to valve seatings and the working parts of valves; if necessary such seatings and parts shall be protected during the cleaning operations. A coal-tar based anti-corrosive paint of thickness 80-100 microns shall be applied to the cleaned surfaces unless otherwise directed by the MEW/Engineer that an epoxy resin coating shall be applied in accordance with the requirements of Section 8 (Materials for Water Works) of these Specifications. All materials shall then be delivered to MEW yard.

Unless otherwise indicated on the Drawings or directed by the MEW/Engineer all existing asbestos cement, steel and cast iron pipes and fittings that are redundant or become redundant as a result of the work carried out under the Contract shall be removed and disposed off where they run under roads and other paved areas and where they are within service reserves indicated on the Drawings. Elsewhere redundant pipes shall be plugged and abandoned in place unless otherwise shown on the Drawings or directed by the MEW/Engineer.

The Contractor shall obtain the MEW's/Engineer's approval prior to the removal of a section of redundant pipework. In certain situations the MEW/Engineer may specify that sections of pipe be abandoned in place and plugged and grouted as specified elsewhere herein.

All materials specified for recovery shall be removed by the Contractor so as to leave them undamaged and suitable for re-use. Repairs to materials damaged in the process of recovery shall be the responsibility of the Contractor.

The method of excavation, taking apart of the pipes, fittings, valves, etc., and the method of backfilling, degree of compaction etc., are to be agreed with the MEW/Engineer prior to the start of such work. Excavation and backfilling will be in general accordance with the relevant Clauses of these Specifications.

All responsibilities of the Contractor set out elsewhere in these Specifications shall apply.

The approximate route of the mains to be removed are shown on Drawings and record drawings showing depths and profiles, valve manholes etc., are available for inspection by the Contractor at the MEW Water Department's Design Section.

The Contractor will be deemed to have studied and made due consideration of the information contained therein on submission of his Tender.

Unless otherwise shown in the Documents or directed by the MEW/Engineer, all valve chambers (including hydrant chambers, washout chambers and the like) on pipelines to be removed shall be demolished and all debris shall be disposed of off-site as required by these Specifications. Prior to demolition, all pipework, fittings, valves, hydrants and the like that are to be recovered shall be removed, cleaned and sand blasted, if necessary. Manhole covers and frames and surface boxes shall be recovered, thoroughly cleaned and then sand blasted if necessary. All materials recovered shall be delivered to the Ministry of Electricity and Water's yard.

Measurement for the removal and recovery of pipes shall be by the metre run for each pipe diameter irrespective of the items of pipe work, fittings, valves, hydrants and the like to be recovered, and shall be measured overall, including valves, hydrants and fittings.

909.02 STEEL PIPELINE REMOVAL, RECOVERY AND DISPOSAL

The method of removing steel pipe is to be agreed with the MEW/Engineer. Where mechanical joints are used they shall be carefully removed, thoroughly cleaned and delivered and stored at MEW yard.

Where pipes with welded joints are to be recovered, the pipe shall be carefully machine cut at the welds and finished by an approved method to remove all burrs and jagged pieces of metal. No other cuts will be allowed without the prior approval of the MEW/Engineer.

and payment for steel pipeline removal and disposal shall be as described in Clause 909.04 hereof.

909.03 ASBESTOS CEMENT AND CAST IRON PIPELINE REMOVAL AND DISPOSAL

Where designated on the Drawings, in the Specifications, or where instructed by the MEW/Engineer, asbestos cement and cast iron lines shall be excavated, removed and carted to spoil off-site and the resultant void backfilled as specified by the MEW/Engineer.

Existing asbestos cement lines which are required to be removed shall be carefully broken, wrapped in polythene sheeting, transported to designated sites and disposed of in a manner recommended and approved by the Environmental Protection Agency. No additional payment will be made to the Contractor for this special method of disposal.

909.04 MEASUREMENT AND PAYMENT

909.04.1 Basis of Measurement and Payment

A. Removal and Recovery of Pipes

Payment shall include for the following, unless otherwise specified herein:

All necessary excavation (in all materials), recovery of pipes, fittings, valves, and hydrants removal of all extraneous material therefrom including the careful removal of concrete surround, thorough cleaning, repair to items damaged by the Contractor, the loading and delivery to the Ministry of Electricity and Water's stores, the unloading and storage as required or as instructed, the backfilling of the excavation as specified or as directed, all reinstatement and removal of surplus material.

Payment per metre run of pipe shall also include for the following work in existing manholes and surface boxes, all necessary excavation (in all materials), careful recovery of fittings, valves, and hydrants, removal of all extraneous material therefrom including the careful removal of concrete surround, thorough cleaning, repair to items damaged by the Contractor, the loading and delivery to the Ministry of Electricity and Water's stores, the unloading and storage as required or instructed, the recovery of manhole covers and frames, and surface boxes, thorough cleaning, repainting, loading, delivery and storage at MEW stores, demolition of valve chamber and the like as specified, backfilling, reinstatement and carting to spoil of unsuitable materials (manhole roof and walls etc.).

The Contractor's attention is drawn to the fact that dewatering may be required in certain areas of the Contract in order to recover pipes, fittings, hydrants and valves. The rates entered in the Bills of Quantities for pipeline removal and recovery shall be deemed to include for al equipment and methods of work, of whatever nature, necessary to complete the works in accordance with these Specifications.

The rates entered in the Bills of Quantities shall be deemed to be applicable to isolated short lengths of pipeline as well as to long continuous lengths.

B. Removal and Disposal of Pipes

Measurement shall be by metre run. Separate measurement for the removal and disposal of asbestos cement, cast iron and steel pipelines shall be made for each pipe diameter and type. Payment shall be as described in item A above, except that the pipes shall be broken out and disposed of off-site as specified herein. However, any cast iron fittings on the asbestos cement lines and mechanical joints on steel lines shall be recovered, cleaned and delivered to the Ministry of Electricity and Water's yard as specified above.

Removal and disposal of pipelines and manholes within the pay limits of excavation of high level areas or structural excavation shall not be measured except for items required to be recovered, but shall be deemed to be included in the rate for excavation. In situations where cast iron fittings on asbestos cement lines and mechanical joints on steel lines are required to be recovered, they shall be grouped together and measured as an item, and payment shall be at the rate indicated in the Bills of Quantities.

The last two paragraphs in item A above shall apply equally to the removal and disposal of pipelines.

909.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
909.1	Removal and recovery of pipes (diameter and type)	m
909.2	Removal and disposal of pipes (diameter and type)	m
909.3	Removal and recovery of fittings and mechanical joints	Item

910 - TREATMENT OF ABANDONED PIPELINES

910.01 PLUGGING AND FILLING OF EXISTING PIPELINES

All ends of abandoned pipelines shall be plugged, as specified herein, and the pipeline either left empty, or filled with concrete or sand/cement grout as specified in the Documents or as directed by the MEW/Engineer.

910.02 PLUGGING OF PIPELINES

Plugging shall comprise placing Class K180 concrete in the end of the pipeline to totally fill the pipe for a minimum length of 1000 mm. The method employed to construct the plug shall be agreed with the MEW/Engineer.

Plugs shall be constructed prior to backfilling where adjacent pipes have been removed and backfilling may commence only on written confirmation from the MEW/Engineer that the plug is acceptable.

910.03 FILLING OF PIPELINES

Where specified on the Drawings or when directed by the MEW/Engineer pipelines greater than 300 mm in diameter shall be completely filled with Class K180 concrete, pipes 300 mm in diameter or less shall, where specified, be filled with sand-cement grout in accordance with Clause 207.07.7 of Sections 2 (Earthworks) of these Specifications.

The Contractor may propose alternative methods of filling the pipe for the approval of the MEW/Engineer, together with detailed costing of the method. If acceptable to the MEW/Engineer any consequential saving shall be passed on to the Employer.

The MEW/Engineer shall retain the right to specify that certain pipes shall be filled as originally specified irrespective of any approval to alternative methods of filling.

Pipe filling shall be carried out prior to backfilling where the adjacent pipes have been removed. Backfilling may commence only on written confirmation from the MEW/Engineer that the filling is acceptable.

Where an abandoned pipeline is specified to remain undisturbed in the ground, the Drawings may show, or the MEW/Engineer may direct, that certain lengths (under existing or proposed roads) are to be filled. The method by which the filling is to be achieved is to be agreed with the MEW/Engineer.

910.04 MEASUREMENT AND PAYMENT

910.04.1 Basis of Measurement and Payment

Plugs to pipelines and pipe filling shall not be measured or paid for separately but shall be considered as incidental to removal of pipelines, valves and fittings.

911 - CONTROL CABLES

911.01 SCOPE OF WORK

At present there are two types of cable used in the MEW water projects networks. One is leased line telemetry cooper cable and the other cable is fibre optic. These cables are used to transfer the SCADA data through wide area network between the various sites of pumping stations, reservoirs and water towers in the southern and northern region of kuwait to the remote Control Centre's location at National Control Centre (NCC) at

shuwaikh, Southern Region Control Centre is located at Mina Abdullah and Northern region Control Centre is located at Doha.

This Section covers the requirements for the Supply of cables, transport to place of work, lay, install, inspection test and commissioning of required and associated materials, complete with all required accessories including excavation for cable trench, backfilling, concrete tiles, steel wire warning tape, R.C tag plate, cable route marker posts, and laying of 160mm, 6.2mm thick HDPE cable duct, RC hand hole/draw pit and R.C manhole etc.

This scope shall include detailed site survey, preparation of new drawings/documentation & updating the existing as built drawings/documents, interface/configure with existing SCADA system and modify data transmission system between these sites. The Contractor's/sub-contractor's responsibility is to obtained the necessary approval from other Ministries.

The Contractor shall modify the existing cable route and supply the necessary cables between the existing splicing manholes. The cables to be laid inside HDPE ducts. The new cables, manholes, handholes/draw pits, cable route marker, tiles and ducts shall comply as per the Specification as described in this Section and the works to be carried out under MEW/Engineer supervision. The installation of cables and accessories shall be similar to the existing installation.

After finishing the splicing of the cables, Optical Time Domain Reflectometer (OTDR) test to be carried between these sites, to ensure that the status, efficiency and attenuation on the copper or fibre optic cables is within the acceptable limits of ranges and confirm that the links and functionality of the system is working effectively. If MEW/Engineer found the test result of copper cables or fibre optic cables are not within the range of limits, the Contractor / sub-contractor then has to do the re-splicing or rectify the problems.

Prior to cutting the existing cables within the Contract limits, the Contractor/sub-contractor has to coordinate with MEW's Water Operation maintenance Department in order to establish that the additional splicing required under the Contract to the existing cables will not affect the efficiency and attenuation of the cables to an extent beyond the allowable limits thus causing the cables not functioning properly. In this instance, the Contractor/sub-contractor has to replace the cables within existing spliced joints, even if the existing spliced joints are beyond the Contract limits, so that the efficiency and the attenuation loss does not exceed the allowable limits.

911.02 LAYING OF CONTROL CABLES

The work shall be carried out by a specialist sub-contractor with considerable experience of similar work. The sub-contractor shall be one of MEW's Water Operation and Maintenance Department's latest approved contractors/sub-contractors. Any work or submittal described herein under Control Cables to be carried by the Contractor is also to mean the approved sub-contractor.

The cable specification and the manufacturer of the cable shall be to the approval of the MEW/Engineer.

The Contractor shall include in the submittal the specifications for the joint boxes and the jointing materials including the sealing compound, ferrules, loading coils, insulating tapes, etc. in accordance with the recommendations of the cable manufacturer. This information is to be scheduled on copies of the Submittal Schedule contained in other of the Contract Documents. The information shall be to the format shown and shall be deemed to be part of the Contract price.

The Contractor shall also include for the supply of special tools such as crimping tools and any other tools necessary for making cable joints.

The Contractor shall include in his offer for the supply and delivery of all cable materials to the Site. Cable ends shall be suitably sealed against moisture.

911.03 SPECIFICATION OF COPPER CABLE

911.03.1 General

The cable shall conform to international standards IEC or BS.
The numbers of pairs are indicated on the Drawings.

911.03.2 Conductors

The conductors shall be 0.92 sq.mm solid soft copper wires. The type and number of cores shall be similar to the existing cable.

911.03.3 Insulation

The conductors shall be insulated with polyethylene. The insulation of the conductors shall be colour coded to the telephone standards of the Ministry of Communications.

911.03.4 Core Assembly

The insulated conductors will be twisted into pairs with varying lengths of lay to minimize cross talk. The number of pairs in the centre and successive layers, the external diameter and a radical thickness of sheath shall be as shown in the Particular Specifications or on the Drawings.

A non-hygroscopic core tape shall be applied over the cable core.

911.03.5 Inner Sheath

The inner sheath shall be polyethylene or PVC.

The PVC shall be of hard grade to IEC 60227 and IEC 60811 with a temperature rating of 90°C. The minimum thickness of the inner sheath shall be as shown in the Particular Specifications or on the Drawings.

911.03.6 Screen

A screen shall be provided by copper tape of adequate width and thickness.
A non-hygroscopic tape shall be used over the screen.

911.03.7 PVC Sheath

The sheath shall be of hard grade PVC used over the screen.

911.03.8 Armouring

Galvanised steel wires shall be used for armouring. The diameter of the wire shall conform to the relevant Specification.

911.03.9 Outer Jacket

The outer jacket shall be of tough PVC highly resistant to abrasion, moisture, weather and environmental cracking and suitable for direct burial underground. The PVC shall have adequate temperature rating.

911.03.10 Characteristics

The characteristics of the cable shall conform to telephone industry standards.

The characteristics of the existing cable to which joints will be made with cables under these Specifications are given below for guidance.

The characteristics of the cable to be supplied under these Specifications shall match those of the existing cable as closely as possible.

911.03.11 Typical Characteristics

a. Loop Resistance (unloaded)
53.4 Ohms per 1000 metres at 20°C.

b. Attenuation
At 800 Hz - 0.728 dB per 1000 metres .
At 1000 Hz - 0.797 dB per 1000 metres.
At 1500 Hz - 0.960 dB per 1000 metres .

At 2700 Hz - 1.250 dB per 1000 metres.

c. Characteristic Impedance

At 800 Hz - 444 Ohms .
At 1500 Hz - 325 Ohms .
At 2700 Hz - 250 Ohms.

d. Inductance

0.625 Milli Henries per 1000 metres.

911.03.12 Typical Characteristics (Loaded)

Cable loaded with 44 MH Coil at 1000 metres.

a. Attenuation

At 800 Hz - 0.29 dB per 1000 metres.
At 1000 Hz - 0.29 dB per 1000 metres.
At 2000 Hz - 0.29 dB per 1000 metres.

b. Characteristic Impedance

At 800 Hz - 925 Ohms.
At 1000 Hz - 920 Ohms.
At 2000 Hz - 912 Ohms.

c. Cut-off Frequency

(Loaded) 3.4 kHz.

911.03.13 Temperature Rating of Cable

Temperature conditions as stated shall be taken into consideration in the cable design. The data given in the Submittal Schedules regarding temperature rating shall be guaranteed.

911.03.14 Cable Drums

The cable shall be packed in an approved cable drums suitable for shipment and handling with the cable ends sealed against ingress of moisture.

The number of cable joints are based on nominal cable length of 500 meters per drum.

911.04 SPECIFICATION OF OPTICAL FIBRE CABLE

911.04.1 General

The cables required are 8 core or 12 core single mode armoured fibre optic cables, as per Site requirements.

The cable construction components comprising inner and outer sheaths, strength, and protection and support shall be metallic armouring, and also integral support wires for suspended cable installation. Cable outer sheaths shall provide cable protection from the effects of continuous exposure to direct sunlight.

911.04.2 Reference Standards

Cable shall be provided and installed in accordance with Fibre Optic Industry Code of Practice for the installation of Fibre Optic Cabling British Standard BS7718:1994 or equal, or unless otherwise specified or approved, the fibre optic telecommunications systems shall comply with the current version of the relevant Reference Standards including those listed below:-

British Standards

BS 7718	Installation of fibre optic cabling
BS9230	Specification for connectors of assessed quality for optical fibres and cables.
BS EN 50081	Electromagnetic compatibility. Generic emission standard
BS EN 187000	Optic fibres
BS EN 188000	Optic fibre cables

Other Standards

BICSI	Building Industry Consulting Service International
TIA	Telecommunication Industry Association
ITU – T	Telecommunication Standardisation Sector of ITU (previously) CCITT – The International Telegraph and Consultative Committee).
G.652	Characteristics of a Single-Mode Optic Cable.

911.04.3 Submissions by the Contractor

911.04.3.1 Scope of Submission

The Contractor shall make submissions to the MEW/Engineer of all design drawings and data sheets relating to fibre optic telecommunications systems and equipment. These submissions shall include, but not limited to, the following:

911.04.3.2 Statement of Compliance

The Contractor shall provide copies of the reference standards used and shall provide a compliance/non-compliance statement.

911.04.3.3 Design Documentation, Drawings and Data sheets

Modify the existing As-Built cable route drawings.

911.04.3.4 Certificates

(a) Manufacturers' works tests
(b) Pre-installation checks
(c) Telecommunications cable test check sheets
(d) Installed telecommunications cable and systems performance tests

911.04.4 Fibre Optic Cable Requirements

911.04.4.1 General

This covers the requirements for filled optical fibre cable to be laid in HDPE ducts.

The optical fibres shall be single mode reduced type secondary protected by loose tubes.

The tubes shall be filled with filling compound and stranded, together with fibres, around a glass fibre reinforced plastic strength member to form a compact and circular core.

The cable structure shall be completed by application of a suitable plastic core wrapping. Over the wrapping an aramide yarn as strength member shall be applied. An UV resistant polyethylene outer jacket shall complete the cable.

The cables shall be suitable for the ambient conditions specified elsewhere.

911.04.5 Armoured Optical Fibre Requirements

The cable structure shall be completed by application of a suitable core wrapping and on APL (Aluminium Polyethylene Laminate) inner sheath. Anti-rodent corrugated steel armour shall be provided. An outer sheath in polyethylene shall ensure good protection.

911.04.5.1 Fibre Requirements

Each single mode optical fibre shall be designed to provide good performance at 1310nm and/or 1550nm.

(i) Fibre Materials

The fibre material shall be manufactured with pure silica cladding and doped silica core in order to guarantee optical transmission performance.

The index profile shall be of matched cladding or segment core design.

(ii) Coating Material

The primary coating shall consist of a composite layer of acrylate (UV cured). The adhesion between the primary coating and the fibre shall also be maintained in the presence of a wet environment

(iii) Optical Characteristics

The optical transmission characteristics shall be homogeneous without discontinuity points and the attenuation shall be verified using OTDR (Optical Time Domain Reflectometer) techniques at 1310nm and 1550nm.

(iv) Secondary Coating

Reclaimed material shall not be used.

The jacket of each fibre shall be loose tube of high modules plastic construction.

The typical outside and inside diameters of the loose tubes shall be 1.05mm and 1.0mm respectively.

Each loose tube shall be filled with a filling compound consisting of fumed silica dispersed in oil to prevent water ingress and to ensure low stress level of the fibre.

(v) Strength Member

The centre of the cable core shall contain a strength member of steel with a typical diameter of 1.5mm or fibreglass reinforced plastic with a typical diameter of 3mm. The diameter shall be defined in accordance with the maximum pulling force declared.

(vi) Fibres Identification

The secondary coating tubes of the fibres shall be coloured for counting of the fibres and counting direction identification. The fibre coating shall be coloured in accordance to the manufacturer standard.

(vii) Filling

The interstices between secondary coating , strength member and core wrapping shall be filled with filling compound to prevent axial and longitudinal flow of water. The filling compound should have the molecular hydrogen absorption property.

(viii) Core Covering

The standard core shall be covered with a synthetic tape with hydrogen absorbing filler.

(ix) Strength Layer

A layer of aramide yarn shall be applied longitudinally on the core covering as strength element.

(x) Outer Sheath

The outer sheath shall consist of a tough weather resistant, UV resistance polyethylene compound.

The sheath shall be circular, free from pinholes, joints, repairs and other defects.

The covering for the metal free design shall consist of a single layer jacket. The jacket thickness shall be in the range between 85 percent and 115 percent of the specified nominal thickness.

More over the jacket thickness shall be, at least, 19% of outer diameter. The jacket eccentricity as defined below shall not exceed 40 percent.

In the design, a single or double layer weather resistant medium or high density polyethylene jacket shall be applied over the armour with a nominal thickness that shall be at least 13 percent of the outer sheath diameter.

(xi) Identification

The outer sheath shall be embossed with the following inscriptions (every 10 meters):

- Manufacture name;
- Standard code;
- Week and year of fabrication;
- Employer;
- Contract name;
- Contractors name;
- Type of Cable;
- Length (every meter).

A progressive metric marker (meters) shall also be printed onto the sheath

(xii) Cable Length

The cable length supplied shall be nominally 8500 m on a single reel.

The reel length shall not deviate by more than minus 0 m to plus 50 m from the nominal drum length.

911.04.5.2 Moisture Barrier Sheath

To prevent moisture penetration, the cable core shall be completely covered with a plastic coated aluminium foil, applied longitudinally with an overlap of at least 3mm. The foil shall consist of a double plated thermo welded aluminium tape with a minimum thickness of 0.1mm ± 0.02mm provided with a protective plastic coating. The thickness of the plastic coating shall be at least 0.003mm.

The aluminium foil shall have electrical continuity throughout the cable length in order to assure that the foil is made from a unique tape.

Outside the aluminium foil a polyethylene sheath shall be executed.

911.04.5.3 Armour

The protective covering shall be made by galvanised corrugated steel tape. The steel armour tape shall be applied longitudinally and thermo welded over the inner sheath, it shall have a nominal thickness of 0.15mm (with a minimum thickness of 0.14 at any point), with a coating (0.06 ± 0.01mm) on both sides to provide corrosion resistance. The tape shall be corrugated with, at least, 12 corrugations per 25mm of cable and longitudinally applied with, at least, 3.2mm lap.

911.05 ENVIRONMENTAL CONDITIONS

The temperatures that prevail in Kuwait shall be taken into account in the design of the cables.

Details of temperature extremes are listed in Clause 800.04 of Section 8 (Materials for Water Works) of these Specifications.

911.06 CABLE DUCTS

911.06.1 Ducts for Copper and Fibre Optic Cables

The ducts shall be manufactured from high density polyethylene (HDPE). The ducts shall be circularly extruded so as to protect the buried cables and shall be a minimum of 160mm bore having 6.2mm thickness.

911.06.1.1 Identification

The ducts shall be embossed with the following inscriptions at intervals of at least 10 meters:

- Manufactures name;
- Standard code;
- Type of Cable running inside duct;
- Length (every meter);
- Week and year of fabrication;
- The letters shall be clearly printed by means of non-metallic paint;
- Guaranteed Performance.

The Contractor shall assure that the duct and joints time of life shall be at least 25 years under the installation conditions.

911.06.1.2 Quality Assurance

The Contractor shall submit a copy of the Quality Certificate to ISO 9000.

911.06.1.3 Inspection and Testing

During manufacturing all the tests shall be performed by the manufacturer in order to assure duct performance. The manufacturer shall carry out tests on incoming goods to verify the integrity of the materials to be used for the manufacturing of the ducts. All line tests shall be certified. Moreover copies of Certificate of Origin relative to primary HDPE material shall be provided. Dimensions shall be tested at random by the manufacturer, one for each duct reel, during the manufacturing process. A copy of all measurement reports shall be provided.

All documentation and measurement about the HDPE duct along the line shall be included in a Quality Control Book, to be produced by the manufacturer and submitted to MEW/Engineer via the Contractor..

911.07 TRENCH EXCAVATION FOR CABLE

Excavation for control cable trenches will be carried out on completion of backfilling to the water main trench, unless otherwise agreed by the MEW/Engineer.

Trenches shall be to a depth of 1.0 m below the final formation level or existing ground level whichever is the lower and in accordance with the routes shown on the Drawings. Bottoms of trenches shall be levelled and smoothed and shall not be less than 450 mm in width. Ducts shall be laid in the trenches on the trench center line. After the ducts are laid the trench shall be backfilled with 300mm of fine selected soil free from lumps, metallic or other foreign matter. Standard cable cover tiles as specified in Clause 911.11 herein shall then be laid centrally along the line of the cable ducts and over them. The remainder of the trench shall be backfilled in accordance with Clause 605.14 of Section 6 (Stormwater Drainage) of these Specifications. Trenches shall be excavated and measured separately from water main trenches, unless otherwise agreed by the MEW/Engineer.

Cable laying, if laid directly in trench, shall be carried out with care. On straight runs the cables shall be laid from the drum directly in the trench and pulled in the trench using an adequate number of rollers. The cables shall be pulled straight, but without undue tension. The cables shall be spaced not less than 50 mm and not more than 75 mm apart. On curved routes the spacing shall be maintained. The method of cable laying shall be approved by the MEW/Engineer prior to the commencement of the work. When required the Contractor shall excavate by hand with or without the use of picks or bars as instructed with no extra compensation.

Cable joints shall be made in the manner recommended by the cable Manufacturer and to the satisfaction of the MEW/Engineer

The Contractor shall fulfill the following requirements:

a. The Contractor shall give the MEW/Engineer twenty-four hour notice in writing that the trench and /or the duct is ready for inspection before backfilling or laying any cables.

b. If the MEW/Engineer does not approve the trench or the duct laid, the Contractor shall make good as directed by the MEW/Engineer and give a new notice or readiness for re-inspection.

Soil conditions and ground levels vary in Kuwait. In some cases, where obstacles such as existing services are met, it may be necessary to lay the cable or the ducts at depths exceeding 1.0 m. Where necessary the Contractor shall make trial excavations ahead of trench excavation to determine the exact location of existing obstacles. The Contractor shall proceed with caution in the excavation and preparation of the trench so that exact location of underground obstacles both known and unknown, may be determined, and he shall be held responsible for all costs resulting from the damage, interruption or breakage of any services, structures or other obstacles.. In the event of any damage, interruption or breakage to the existing facilities and services during the progress of the works due to the failure of the Contractor to exercise proper precautions, the Contractor will be held liable for all costs resulting from the damage, interruption or breakage of the said facilities and services.

The Contractor shall, at his expense, pump out all water or sewage which may arise or be brought into excavations of any kind from the existing sewers, drains and water courses or from rainfall or flash storms and shall, where necessary, thoroughly drain the works.

Where cables cross certain major roads they shall be located in reinforced concrete culverts which will also contain the water mains. Cables shall be drawn through ducts fixed to the concrete walls as shown on the Drawings. The Contractor is to include in his rates for the supply of the necessary materials and the labour required for the fixing. At some locations where cables cross roads they shall be laid in 160 mm diameter ducts and surrounded by concrete as shown on the Drawings.

The rates given for excavation shall be deemed to include for all costs involved in complying with the Clauses under this Section of the Specifications. The Contractor shall be allowed no extra compensation for any reason whatsoever.

911.08 INSTALLATION OF DUCTS FOR FIBRE OPTIC AND COPPER CABLES

911.08.1 Installation of Ducts for Copper and Fibre Optic Cables

The duct installation for fibre optic cables shall be 750 m (maximum) straight stroke, with draw pits between them, to ensure the installation of the draw rope, the place for fibre optic cable joints and easier hauling of the cable. The duct installation for copper cables shall be between handholes/draw pits.

911.08.1.1 At Crossings

(i) Open Air Crossing

The duct shall be fixed to the pipeline with proper attach clamps.

(ii) Casing Pipe Crossing

If the pipeline is protected by concrete culvert, the duct shall be fixed on the ceiling of the culvert with proper support.

(iii) Pipeline crossing

In the case of pipeline crossing, the duct shall be laid above the pipeline at a minimum distance of 300mm, constituted of sand bags.

911.08.1.2 Duct Splices

The splicing between segments of duct should be done at least 24 hours after the laying, to be sure that the duct has met the final configuration.

All the splices shall be done by a butt welding machine and it shall be faultless to minimise its resistance in cable pulling.

Alternatively compression joints should be used.

911.08.1.3 Accessories

All the required components to make the duct continuous and useful fore installation of the fibre optic cable, which are:

(a) Nylon Rope – To haul the steel pulling in rope for the fibre optic cable or hauling the copper cable.
(b) End Plugs – To close the ends of the duct.
(c) Open End Plugs – To close the end of the duct and centre the cable.
(d) Pushing Mandrel – to haul the draw rope into the duct with an air compressor.

911.08.1.4 Installation of Draw Rope

A nylon draw rope shall be placed into the duct to successfully haul the steel wire for installation of the fibre optic cable or to haul the copper cable.

The installation shall be made using a compressed-air pushing mandrel, with diameter slightly smaller than that of the duct, that carried the draw rope from one end of the duct to the other.

This operation shall be done immediately after duct covering to be sure that the duct has no damages or obstructions.

911.09 INSTALLATION OF WARNING TAPE

A warning tape shall be provided to warn of the presence of the duct and the relative fibre optic or copper cable to avoid eventual damage to the duct during an excavation.

It shall be in red polyethylene, alkaline and acid chemical agent proof, 50 mm wide, 1.0 μn thick and shall be wound onto reels 300 – 400 m in length.

Installation of warning tape shall be done during covering, on the vertical axis 300 mm above the duct.

The tape shall be arranged continuous making splicing only where necessary.

The warning tape shall be signed in black in English and Arabic, if appropriate. The tape shall read: **CAUTION! (FIBRE OPTIC/COPPER) TELECOMMUNICATION CABLE. "P10 –D3 WATER TOWERS'' (example)**

911.10 INSTALLATION OF CONCRETE HANDHOLES/DRAW PITS

The duct shall be interrupted at every vortex more than 45°, to insert a concrete handhole/draw pit, which is 1.2 x 1.2 m typical and have vertical walls to permit duct entry in every direction.

The position of every handhole/draw pit will be specified and the Contractor shall respect the following directives:

-The excavation to place the handhole/draw pits shall be 200 mm larger than the pits.

-After the excavation the laying surface shall be levelled to lay the handhole/draw pit perfectly horizontal.

-If the handhole/draw pit is a pre-formed one and made of more than one element, the elements shall be sealed by concrete mortar.

-The duct shall be inserted into the handhole/draw pit for at least 100mm, and the entry shall be sealed by concrete mortar.

-The base of the handhole/draw pit shall have a hole to drain water.

911.11 INSTALLATION OF UNREINFORCED CONCRETE TILE SLAB

Unreinforced concrete tile slabs shall be made of concrete class K250, and in sizes 400 x 350 x 10mm thick, having the following wording cast in English and Arabic on their upper surface:

M.E.W – W.P.D

Instrument and Control cable

The slabs shall be laid below the warning tape, on vertical axis 200mm above the duct.

The Contractor shall submit Test Certificates for the tiles to the satisfaction of the MEW/Engineer.

911.12 INSTALLATION OF CABLE ROUTE MARKER POST

Cable route markers comprise of 63mm diameter galvanised steel painted posts, partly cast in concrete base, and having 350 x 400mm warning sign fixed at the top. The overall height of the route marker is to be 1600mm above ground level, all as shown on the Drawings or as directed by MEW/Engineer.

911.13 MAPPING AND RECORDING

The Contractor shall store on the appropriate sheets, all the handholes/draw pits, duct splices or reparations, special protections, etc. to make the positions easily detectable, specially:

- Every cable position change or pipeline crossing;
- Crossing in casing pipe/in culverts;
- Splices and or reparations;
- Progressive metric marker.

All duct splices or reparations shall be stored also on the splices diagram.

911.14 INSTALLATION OF CABLES

911.14.1 Installation of Copper Cables

Cables shall be pulled between handholes/draw pits by means of draw rope which is installed inside of the duct.

Cable jointing shall be carried out according to the recommendations of the cable manufacturer. The Contractor shall submit for the approval of the MEW/Engineer details of the method and procedures of the cable jointing he proposes to use, giving details of the materials to be used.

The Contractor shall submit for MEW's/Engineer's approval the spacing of the loaded joints and the value of the inductance of the loading coil to achieve the characteristic specified elsewhere in these Specifications.

911.14.1.1 Control Cable Terminal Boxes

The Contractor shall supply, install and connect terminal boxes at locations shown on the Drawings.

Terminal blocks shall be of the stud and nut type with bridging links for insulation of each terminal and capable of receiving crimped tags to be secured by nut and bolt.

The cable ends will be made up and crimped to terminal lugs. The lugs will be secured to the terminal block tags. Crimping type lugs will also be included. Solder tag type terminals will not be accepted.

911.14.1.2 Cable Records

The Contractor shall engage at least one qualified surveyor and one qualified draughtsman to furnish the cable records.

The Contractor shall prepare the cable records taking accurate measurements at site in an approved manner and

these measurements shall be approved by the MEW/Engineer before backfilling of the trenches.

The records shall show the location of loaded and unloaded joints.

The Contractor shall hand over the cable records after completion of each cable line. The Contractor shall also hand over to the MEW/Engineer all the preliminary working sheets or records prepared at Site.

No separate measurement and payment shall be made for preparing the cable records which will be deemed to be included with the relevant items to which it applies.

911.14.2 Installation of Fibre Optic Cables

The installation of the fibre optic cable into the duct consists of:

- First simple visual inspection of the cable integrity;
- Cable reel allocation;
- Lay of the cable.

For these operations the Contractor shall provide specialised personnel with the necessary tools and instruments.

These operations shall be done respecting the project specifications and mechanical characteristics of the cable.

911.14.2.1 Preliminary Services

Prior to starting the services, an on-site analysis of the ducts shall be made, to determine the cable reel allocation, the points where to thread the cable into the duct and to place cable rollers.

The nylon draw rope shall be situated with the steel pulling rope by a capstan winch that haul the rope to the point where the cable reel shall be positioned.

An articulated anti-torsion joint shall be fixed to the end of the steel rope and, with a hauling sleeve, bind at the end of the cable.

911.14.2.2 Cable Pulling – In

A capstan winch with a mechanical fuse that protects the cable from excessive tension stresses shall do the cable pulling-in.

An appropriate lubricant should be used to facilitate cable pulling-in, applying it both on the cable and the duct.

If more than one capstan winch is available, the other ones should be positioned in middle draw pits to provide synchronous cable pulling and more than 1 Km pulling at once.

If the cable has to be pulled-in in two directions, the cable shall be positioned at the centre of the spread and the cable pulled-in in one direction, then the cable left shall be figured in eight shapes to be pulled-in in the other direction with the same method.

After the cable has been pulled-in into the duct, appropriate end caps shall cover the cable ends.

911.14.2.3 Cable Positioning in Draw pits

In all draw pits a cable spare of about 5 m shall be placed; in the draw pits where a cable splice should be done, a cable spare of 12 m for cable end shall be placed.

If more cable exceed, the cable spare shall be distributed along intermediate draw pits.

Open-end plugs shall block the cable exit from the line duct.

911.14.2.4 Termination and Splicing of Fibre Optic Cable

The system shall be designed to operate in ambient site and climatic conditions. For outdoor splice enclosure and underground splice enclosure, the Contractor shall guarantee correct operation under the prevailing site and climatic conditions.

(I) Optical Termination

Optical fibre cable shall be terminated on suitable Optical Distribution Frames (ODF). All fibres in the cable shall be terminated in the ODF.

Termination shall utilise FC-PC type connectors for all fibres (spare and used) in the cables. All spare fibre terminations shall be sealed with proper caps to prevent entry of dust or other contaminants to the fibre end..

Losses for the connection coupling shall not exceed 0.5 dB and each shall be considered in the power budget calculations.

For each fibre optic link, a minimum of 3 dB safety margin should be provided after accounting for the following losses:

- Connectors losses
- Cable Attenuation
- Splice losses
- Future cable splices losses. This shall normally be taken as 3 dB.

(II) Optical Splicing

The splicing of optical fibres shall be made by arc-fusion method. The single splices, together with surplus length of fibre, shall be arranged in an orderly way into a proper splice enclosure.

The maximum splice loss for each fibre link shall not exceed 0.2 dB, however the average splice loss for each fibre link shall not exceed 0.1 dB.

The minimum number of intermediate splices shall be utilised, compatible with a suitable cable overhead installation or laying in trench strategy.

Splices shall be housed in outdoor or underground fully weather sealed enclosures especially designed. The IP rating for outdoor enclosures should be IP 66, but minimum IP 65 shall be assured and certified in case of outdoor/above ground splices. If the splicing points are underground, the IP rating for such enclosures shall be certified as IP 68.

All splices shall be clearly numbered in an overall numbering scheme, which shall be detailed in the as built documentation. These numbers shall also appear on surface splice enclosures. At splice enclosures the cables shall be marked upon entry indicating the destination of each cable end. All fibres shall be spliced for each optical section.

911.15 TESTING

911.15.1 Testing Copper Cables

Each section of the cable shall be tested before jointing, and cables and joints shall be tested after jointing.

Test procedures and test instruments to be used shall be approved by the MEW/Engineer before any instruments and/or equipment are ordered by the Contractor.

The Contractor shall provide test instruments and skilled personnel for carrying out the tests. Instruments shall carry a current test certificate of approval from an approved testing authority.

The cable jointing and the tests shall be carried out under the supervision of the MEW/Engineer.

The test shall include, but not necessarily be limited to, the following.

a. Continuity test
b. Insulation test
c. Cable characteristics, unloaded and loaded
d. Loop capacitance
e. Attenuation
f. Soundness of joints
g. Cut-off frequency

If the tests are not satisfactory the MEW/Engineer may require the Contractor to remake the joint and the Contractor shall do so at his own expense including the supply of materials and labour to the satisfaction of the MEW/Engineer. The tests shall be repeated at the Contractor's expense.

The satisfactory test results shall be recorded for each joint and section of the route and six hard copies and two soft copies of each record shall be submitted as part of the record drawings by the Contractor.

When testing the cables, in addition to his own instruments/equipment for testing, the Contractor will be allowed to use, if necessary, MEW's testing instruments/equipment located in MEW's Control Centre related to the cable to be tested, in the presence of the responsible MEW's engineer. The Contractor will be liable to repair or replace any instrument/equipment belonging to MEW which is damaged by him while he is carrying out testing operations in the Control Centre.

911.15.2 Testing Fibre Optic Cables

911.15.2.1 Generally

Various tests outlined in this Clause supplement testing Clauses within this Section of the Specifications. Where any discrepancy or contradiction arises between these various Clauses of the Specification, the Fibre Optic systems testing Clauses shall take precedence and supersede those other testing Clauses.

911.15.2.2 Dimensional Tests On Fibre Optic Cable

The Contractor shall carry out tests on incoming goods, to verify the integrity of the materials manufactured.

Tube dimension:	Inner diameter measurement
(With tolerance ±10%)	Outer diameter measurement
Sheath thickness:	Nominal measurement
(With tolerance ±10%)	Average measurement
Outer diameter:	Minimum measurement
(With tolerance ±10%)	Nominal measurement

911.15.2.3 Factory Acceptance Test for Armoured Optical Fibre Cable

The tests shall include for each testing length optical time domain reflectometry measurement for testing length and attenuation. For runs over 100 meters, the test shall be made at both ends and the two measurements compared. Differences greater than that which can be caused from instrument resolution shall be investigated and resolved.

Attenuation shall be measured to ensure compliance with the design Specification.

The measurements shall be summarised in a graphic (back scattering diagram) which shall also be used for localised losses detection during installation.

In particular the test carried out by the supplier shall be the following:

- Attenuation measurements for each fibre in dB/km (average and maximum) in all the cable lengths of the supplied lot.
- General inspection on construction conformance.

Moreover for each fibre:

- Attenuation coefficient for 1310nm and 1550nm,
- Zero dispersion wave length,
- Zero dispersion slopes,
- Chromatic dispersion at 1550nm.

All cables with values above the specified shall be rejected.

Tests to be performed by the supplier witnessed/certified and approved by the Contractor in the presence of MEW/Engineer or a third party approved by MEW/Engineer. Tests shall demonstrate that the fibre optic system has been provided and constructed in accordance with the Specifications and Standards.

The Contractor shall submit a comprehensive test schedule for the MEW's/Engineer's approval at least 4 weeks prior to the start of the test.

Moreover, the Contractor shall demonstrate that the following type tests or equivalents were performed on fibre optical cable in a manner to guarantee the quality of the production process.

Description	**Minimum Requirement**
Compressive strength	12.6 N/mm
Impact Resistance	50 N.m, cycles, 0.5 Hammer Radius 10 N.m, 10 cycles, no fibre break
Cable twist	10 cycles, 180° twisting, 2.0 meter sample
Tensile load	Static: 1000N Dynamic: 2700 N (At 3400N no fibre break)
Water penetration	3 meter sample, 1 meter water pressure, 24 hours
Compound flow test	No drip at 80 °C
Repeated bending	500 cycles, 100 N cable load, 20 x OD Bend radius, 30±1 cycles/minute, 5 meter sample minimum.
Temperature cycling	-20°C to 80°C
Jacket adhesion strength	1.8 N/mm
Bed radius	Armoured:15 x OD (Static) 20 x OD (Dynamic) Non armoured: 10 x OD (static), 20 x OD (dynamic)

- The average increase in attenuation for the fibre of a cable subjected to this load shall not be greater than 0.10dB, and no measurable increase in attenuation shall be evident after the load removal.

- The cable sample shall withstand impact testing without exhibiting any average increase in attenuation greater than 0.20 dB. The cable jacket and armour (if present) shall not exhibit evidence of cracking or splitting.

- The cable sample shall be capable of withstanding mechanical twisting without experiencing an average increase in attenuation greater than 0.10 dB.

- The average increase in attenuation for the fibre of a cable subjected to the dynamic load shall not be greater than 0.10dB. The cable shall not experience a measurable increase in attenuation when subject to the static load.

- The cable sample shall be capable of withstanding mechanical flexing without experiencing an average increase in attenuation greater than 0.10 dB at the completion of the test. The cable jacket and armour (if present) shall not exhibit evidence of cracking or splitting under 10 times magnification.

  The change in attenuation at extreme operational temperatures shall not be greater than 0.20 dB/km, with 80 % of the measured values no greater than 0.10 dB/km. The measurement shall be made at 1550 nm wavelength.

  Four test samples shall be taken on the overlap region shifted 90° one from the other.

- The average increase in fibre attenuation at the extreme test temperatures shall not be greater than 0.20dB. The cable jacket and armour (if present) shall not exhibit evidence of cracking or splitting.

Environmental Characteristics

- Low temperature test

  The maximum variation of attenuation at 1310 nm and 1550 nm between ambient temperature and -30°C is within the measurement error of the apparatus.

- Temperature cycling

  The maximum variation of attenuation at 1310 nm and 1550 nm with respect to ambient temperature in the range between -60°C and + 80°C is 0.05 dB/km.

Special tests

The Contractor shall demonstrate by means of suitable certification that the following type tests or equivalent were performed on the fibre optical in manner to guarantee the quality of the production process.

- Tensile breaking strength on long sample can be given in the Weibull distribution form,
- Bending,
- Very high temperature resistance (e.g. 180°C or +200°C),
- Nuclear radiation,
- Stress corrosion susceptibility factor N,
- Dynamic strength,
- Abrasion,
- Micro bending sensitivity.

911.15.2.4 Acceptance Test (Final Inspection)

The tests shall include for each testing length optical time domain reflectometry measurement for testing length and attenuation. For runs over 100 metres, the test shall be made at both ends and the two measurements compared. Differences greater than that which could be caused from instrument resolution shall be investigated and resolved. Attenuation shall be measured to ensure compliance with the design Specification.

The measurements shall be summarised in a graphic (Back Scattering Diagram) which shall also be used for localised losses detection during installation. In particular the tests carried out by the Contractor shall be the following:

Attenuation measurements for each fibre in dB/km (average and minimum) in all the cable lengths of the supplied lot.

Moreover for each fibre:

- Attenuation coefficient for 1310 nm and 1550 nm
- Zero dispersion wave length
- Zero dispersion slopes
- Chromatic dispersion at 1550 nm

All cables with values above the specified will be rejected.

Tests to be performed by the Contractor, witnessed/certificated and approved by third party inspectors or MEW/ Engineer in accordance with inspection data sheet, and shall demonstrate that the fibre optic system has been provided and constructed in accordance with the Specifications and applicable Standards. The Contractor shall submit the relevant information to the third party or to MEW/Engineer at least four (4) weeks prior to the start of the test.

When testing the cables, in addition to his own instruments/equipment for testing, the Contractor will be allowed to use, if necessary, MEW's testing instruments/equipment located in MEW's Control Centre related to the cable to be tested, in the presence of the responsible MEW's engineer. The Contractor will be liable to repair or replace any instrument/equipment belonging to MEW which is damaged by him while he is carrying out testing operations in the Control Centre. Instrument/equipment available in the Control Centre which the Contractor may select to use in carrying out testing of the cable are:

a. Optical Line Terminal Equipment (OLTE)
b. Communication Supervisory System
c. Primary Multiplexor with Voice and Data Interfaces
d. Alarm Detection
e. Digital Branching Equipment
f. Channel Interfaces

911.16 WORK IN TILED/BLOCKED PAVEMENT

Removal and restoration of concrete tiles/blocks shall be carried out in accordance with the requirements for such work specified in Section 17 (Utilities Structures) of these Specifications.

911.17 MEASUREMENT AND PAYMENT

911.17.1 Basis of Measurement and Payment

a. General
Measurement and payment for pipe ducts shall be in accordance with Clause 1702.08 of Section 17 (Utilities Structures) of the Specifications stating the type..

b. Control Cables
Measurement and payment for control cables shall be in accordance with the criteria described in Clause 1404.01 of Section 14 (Lighting and Electrical Works) of the Specifications stating the type. Rates shall include for cable cover tiles, loaded pairs, jointing and splicing materials, control cable terminal boxes, optical distribution frames and testing.

c. Trench
Measurement and payment for trench shall be in accordance with the criteria described in Clause 1402 of Section 14 (Lighting and Electrical Works) of the Specifications. Rate shall include excavation and backfilling,cable protection, all necessary accessories as specified.

d. Ducts
Measurement and payment for ducts in concrete shall be in accordance with the criteria described in Clause 1402 of Section 14 (Lighting and Electrical Works) of the Specifications. Rate shall include supplying and laying the ducts,all necessary jointing accessories ,supplying and laying of concrete, ducts markers slabs ,all necessary accessories as specified.

e. Manholes and Handholes/Draw pits
Measurement and payment of manholes and handholes/drawpits, including adjustment and/or demolition of existing manholes and handholes/draw pits shall be in accordance with Clause 2101.14 of Section 21 (Telephone Works) of the Specifications.

f. Payments

Payments shall be made under Section 9 of the Bills of Quantities and the rates shown in the Bills of Quantities shall be full compensation for furnishing all required materials, labour, tools, equipment and all incidentals as specified or as required to complete the work.

911.17.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
911.1	Control cable (type)	m
911.2	Trench for control cable	m
911.3	HDPE ducts for control cable (size)	m
911.4	HDPE ducts encased in concrete for control cable (size)	m
911.5	Manhole (size)	nr
911.6	Handhole/Draw pit (size)	nr

912 - SUBMITTAL SCHEDULE

912.01 GENERAL

The Contractor shall submit within 30 days after Date of Enterprise a completed copy of the Submittal Schedule referred to under Clause 911.02 of these Specifications and contained in other of the Contract Documents, samples of which follow:

CONTROL CABLES

SUBMITTAL SCHEDULE

(Sheet 1 of 5)

TECHNICAL DATA

The data required in this Submittal schedule must be filled in by the Contractor for the approval of MEW/Engineer..

CONTROL CABLE

CABLE CONSTRUCTION

1.	Conductor diameter	……..	mm.
2.	Conductor material	……..	
3.	Conductor insulation and temperature	……...	
4.	Twisted Pairs	……...	Yes/No
5.	Colour coding conforms to Specification	……...	Yes/No

6. Submission No …… giving details of colour coding for central and outer layers for the cables covered by this Specification ……...
7. Conductor core covered by a non-hygroscopic tape……... Yes/No

8.1	Material for Inner Sheath	……
8.2	Minimum thickness of Inner Sheath	…….30 pairs …… 15 pairs …….. 10 pairs
9.	Temperature rating	……...
10.	Screen :	
	Copper tape width	……...
	Thickness	……...
11.	Sheath over Screen:	
	Material/to specification	……...
	Sheath radical thickness	……...
	Temperature rating	……...

SUBMITTAL SCHEDULE

(Sheet 2 of 5)

12.1 Armouring by galvanised steel wires …… Yes/No

12.2 Wire diameter …….30 pairs …… 15 pairs …….. 10 pairs

13. OUTER BRAIDING

PVC braiding …….30 pairs …… 15 pairs …….. 10 pairs

thickness of braiding ……...

material to Specification ……...

temperature rating ……...

CHARACTERISTICS

14. Conductor resistance at 20°C …… OHMS/1000 Mtr.

15. Insulation resistance …… MEG OHMS/ 1000 Mtr.

16. Dielectric strength

Insulation capable of withstanding for …… seconds

between conductors ……... volts

between conductors and shield ……... volts

17. Average mutual capacitance (at 1kHz) …… nf/1000 Mtrs.

18. ATTENUATION

At 800 Hz ……..…… dB/1000 Metres

At 1000 Hz ……..…… dB/1000 Metres

At 1500 Hz ……..…… dB/1000 Metres

At 2700 Hz ……..…… dB/1000 Metres

19. INDUCTANCE

SUBMITTAL SCHEDULE

(Sheet 3 of 5)

20. CHARACTERISTIC IMPEDANCE

At 800 Hz OHMS

At 1500 Hz OHMS

At 2700 Hz OHMS

21. CROSS TALK LOSS FAR END LOSS AT ……kHz.…… dB/1000 Metres

CHARACTERISTIC LOADED

Cable loaded with ……...Milli Henry Coil At 100 meters

22. ATTENUATION (LOADED CABLE)

At 800 Hz …….. dB/1000 Metres

At 1000 Hz ..... dB/1000 Metres

At 2000 Hz. ..... dB/1000 Mettes

23. CHARACTERISTIC IMPEDANCE (LOADED CABLE)

At 800 Hz ..... OHMS

At 1000 Hz ..... OHMS

At 2000 Hz ..... OHMS

24 CUT OFF FREQUENCY (LOADED)…….. kHz

25 CABLE DRUMS 30 pairs 15 pairs 10 pairs

Drum size and weight

Diameter m/ft .....

Width m/ft .....

Weight kg/lbs …….

Cable length m ……

SUBMITTAL SCHEDULE

(Sheet 4 of 5)

26 Cable Manufacturer ……..
Address ……..

27. JOINT BOXES
Manufacturer ……
Address ……
Type No ……..Loaded ……..Not Loaded …….
Dimensions and Weight
Details included Yes/No
Submission ……

28 SEALING COMPOUND
Name of Manufacturer ……
Address ……
Compound Type ……
Conforms to Spec ……
Pouring Temperature ……°C
Dielectric strength ……

29 CABLE JOINTING FERRULES
Name of Manufacturer ……
Address ……..
Type of Ferrule ……
Dimensional details included ……. ……Yes/No
Submission ……

SUBMITTAL SCHEDULE
(Sheet 5 of 5)

30. INSULATING TAPES

Name of Manufacturer .....

Address …….

Type of Insulating tape …….

Conforms to Spec …….

Dielectric Strength ……

REQUEST FOR MATERIAL INSPECTION – CHECK LIST:-
(Fiber optic cable work)

Project:-

Contractor:-

Please be advised that the works to be carried out in the above location are entirely complete And are ready for inspection.				
Inspection required		Date:		Time:
Subject	Fiber optic cable drum Visual and Attenuation test inspection (before laying)			
Location	…….			
B.O.Q No	Shop Dwg:-	Spec Section:-	Clause No:-	
Description of works to be inspected	1	Visual inspection		
	2	Optical splicing		
	3	Cable pulling-In		
	4	Optical termination		
	5	HDPE cable duct		
	6	Duct splices		
	7	Installation Draw rope		
	8	Installation of warning tape		
	9	Concrete draw pits Manhole/Hand hole		
	10	Mapping and recording (Route marker/identification)		

Enclosed documents/ Drawings: 1. Visual and Attenuation test inspection report. 2. Manufacturer Factory test reports.
Comments: The Contractor agreed to make the attenuation test after laying/before splicing the F.O Cable.
NB: This checking & approval shall not relieve the Contractor of his obligation to perform the work in accordance with the Contract Specification/Documents.

ME W – Projects:- _____ _____ _____ _____ Engineer's representative Name Signature Date Time
MEW – O&M:- _____ _____ _____ _____ Engineer's representative Name Signature Date Time
Contractors _____ _____ _____ _____ representative Name Signature Date Time

Visual and Attenuation test reports

1. Cable Identification No.:
   Drum No. :
   Length (meters) :
   Attenuation test results :

Fiber count	Tube colour	Fiber colour	Attenuation			
			DB/kilometer		total loss	
			1310nm	1550nm	1310nm	1550nm
1	Blue	Blue				
2	Blue	Orange				
3	Blue	Green				
4	Blue	Brown				
-						
-						
12						

Average Attenuation (DB/KM) =
Max Attenuation (DB/KM) =

2. Cable Identification No.:
   Drum No. :
   Length (meters) :
   Attenuation test results :

Fiber count	Tube colour	Fiber colour	Attenuation 1310nm 1550nm total loss			
1	Blue	Blue				
2	Blue	Orange				
3	Blue	Green				
4	Blue	Brown				

Average Attenuation (DB/KM) =
Max Attenuation (DB/KM) =

3. Cable Identification No.:
   Drum No. :
   Length (meters) :
   Attenuation test results :

Fiber count	Tube colour	Fiber colour	Attenuation 1310nm 1550nm total loss			
1	Blue	Blue				
2	Blue	Orange				
3	Blue	Green				
4	Blue	Brown				

Max Attenuation (DB/KM) =

SECTION 10: SITE LABORATORIES

1000 - SITE LABORATORIES

1000.01 DESCRIPTION

The Contractor shall provide, construct, furnish, equip and maintain material testing laboratories for the Engineer and his staff on sites shown in the Contract Documents or approved by the Engineer.

Necessary payments for the hire of the sites and for the preparation of the sites shall be made by the Contractor, at his own expense, at rates to be set by the Ministry of Finance unless otherwise provided for in the Contract Documents.

The Contractor shall make all necessary preparations of the sites to receive the laboratories.

1000.01.1 Office for Site Laboratory

In addition to the areas required for each laboratory as specified in Clauses 1001.02,

1002.02 and 1003.02 herein, each laboratory shall also be provided with the following as a minimum :
Office 1 3.25 m x 3.00 m
Office 2 3.25 m x 3.00 m
Two toilet rooms as specified herein; opening only from the Materials engineer's office.
One Kitchen Facility as specified herein.

The Contractor shall furnish, install and maintain the following furniture in the Offices:

Item	Quantity
Desk double pedestal, 0.8 m x 2.0 m	1
Table, Reference 1.2 m x 1.8 m	1
Chair, swivel on castors (cloth upholstery)	1
Chair, without arms (cloth upholstery)	3
Filing Cabinets (locking) 4 drawer, legal size	3
Bulletin Boards 1.2 m x 2.5 m	2
Book Shelves 1.0 m x 1.0 m, 3 shelves	3
Safety Helmets (White or Yellow)	6
Yellow Reflective Jackets	6
Filing Trays, waste paper basket, ashtray	2 sets
General Office Equipment: punch, stapler, staple puller, sharpener	1 set
Desk Calculator, electronic scientific with printout	1
First Aid Box	1
Fire Extinguisher	2
Automatic Water Cooler	1
5 m pocket tape	3
30 m steel tape	1
50m linen tape	1
Emergency light system (generator)	1
Safety shoes	3
Pocket Torch	2
Camera for field/laboratory	1
Computer/LaptopFax Machine	2

The Contractor shall supply and keep replenished all necessary stationery (A4 pads – plain, coloured, lined, millimetre squared, logarithmic, etc.), all necessary standard forms, pens, pencils, coloured crayons, felt tip pens, erasers, etc. all of the type and in the quantities specified by the Engineer.

Each office shall be provided with electric lighting and power and one telephone service for use by the Engineer for all local calls.

The Toilet Rooms shall be equipped with a water-closet (pedestal type), wash basin with hot/cold water, hot water heater, wall mirror and shower unit complete with shower curtain. All necessary supplies (soap, towels, toilet paper, etc.) for the toilet room shall be provided and kept replenished at all times by the Contractor. The toilet rooms shall be properly ventilated by an extractor fan to the outside of the building.

The kitchen shall be equipped with a gas cooker (2 rings plus oven minimum), together with necessary gas cylinders in a properly ventilated store, microwave oven (minimum power 900W), refrigerator (minimum size 150 liters), water filter, hot and cold water, electric kettle, cooking equipment (pans, saucepans, utensils, etc.), crockery and cutlery, all of the type and in the quantity approved by the Engineer. The kitchen shall be properly ventilated by an extractor fan to the outside of the building.

The Offices, Toilet Room and Kitchen shall be air-conditioned and shall be for the sole use of the Engineer. Heating facilities, to be agreed with and approved by the Engineer, are to be provided for the Offices, Toilet Room and Kitchen.

Covered parking facilities for 6 vehicles shall be provided adjacent to the facilities.

1000.01.2 Standards and Codes

The following list of codes and standards, together with any additional codes and standards noted in the Contract Documents, will be used by the Engineer to check that the Works are carried out in accordance with these Specifications. Unless otherwise stated, the dates of each standard and code in the following list, together with any additional standards and codes noted in the Contract Documents, shall be their latest editions including supplements and amendments.

Unless specified otherwise in the Contract Documents, the Contractor shall retain on site, within 90 days from the Date of Enterprise, a copy of each code and standard listed below and noted elsewhere within this General Specification and other Contract Documents for the exclusive use of the Engineer. Each Standard and Code provided shall be an original document from the authority which published that standard or code. Clear, bound photocopies or bound electronically transmitted copies will be accepted if the originals are not available. Should the Contractor fail to provide the codes and standards within this period, unless proof is provided that satisfactory orders were placed within 45 days of signing the Contract, he shall incur a penalty of Kuwaiti Dinars One Hundred (KD 100) per day until such time as the necessary codes and standards are provided on Site to the Engineer's satisfaction.

Unless specified otherwise in the Contract Documents, on completion of the Project the standards and codes will become the property of the Employer.

No separate measurement or payment shall be made for standards and codes, but they shall be considered subsidiary requirements the cost of which shall be deemed to be included in the Contractor's overall price.

LIST OF CODES AND STANDARDS

Asphalt Institute:

Manual MS2

American Concrete Institute:

ACI, Volumes 1 to 5

American Society for Testing and Materials (ASTM)

Annual Book of ASTM standards: Volume 00.01 Subject Index; Volume 01.01 Steel – Piping, Tubing, Fittings; Volume 01.04 Steel – Structural, Reinforcing, Pressure Vessel, Railway; Volume 01.06 Coated Steel Products; Volume 02.02 Die-Cast Metals, Aluminum and Magnesium Alloys; Volume 04.01 Cement, Lime, Gypsum; Volume 04.02 Concrete and Mineral Aggregates; Volume 04.03 Road and Paving Materials, Traveled Surface Characteristics; Volume 04.08 Soil and Rock, Building Stones; Volume 06.01 Paint-Tests for Formulated Products and Applied Coatings; Volume 06.02 Paint-Pigments, Resins and Polymers; Volume 08.01 Plastics (I); Volume 09.01 Rubber, Natural and Synthetic

All other ASTM Standards referenced within the Contract Documents that are not included in the above

volumes shall also be supplied by the Contractor.

American Association of State Highway and Transportation Officials (AASHTO)

Standard Specifications for Transportation Materials and Methods of Sampling and Testing.
Part 1 – Specifications
Part 2 – Methods of Sampling and Testing
Standard Specifications (LRFD) for Highway Bridges – Design and Construction
Guide for Selecting, Locating and Designing Traffic Barriers.
Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

British Standards (BS) and Code of Practice (CP)

Standard	Title
BS 4:05	Structural steel sections. Specification for hot-rolled sections
BS 10:09	Specification for flanges and bolting for pipes, valves and fittings
BS 1:85/BS EN 10226-1	Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads (metric dimensions)
BS 65:91	Specification for vitrified clay pipes, fittings and ducts, also flexible mechanical joints for use solely with surface water pipes and fittings
BS 78:65	Specification for cast iron spigot and socket pipes (vertically cast) and spigot and socket fittings. Part 2 – Fittings.
BS 88:07	Low-voltage fuses. Supplementary requirements for fuses
BS 143:00	Threaded pipe fittings in malleable cast iron and cast copper alloy
BS 5400:06	Steel , Concrete, and Composite Bridges
BS 159	High-voltage busbars and busbar connections power transformers
BS 188:77	Methods for determination of the viscosity of liquids
BS 449-:69	Specification for the use of structural steel in building. Metric units
BS 476:87/Parts 20,21,22,23	Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction
BS EN 512:95	Fibre-cement products. Pressure pipes and joints
BS EN 124:94	Gully tops and manhole tops for vehicular and pedestrian areas. Design requirements, type testing, marking, quality control
BS 5911-3:02/BS EN 1917:02	Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete manholes and soakaways
BS EN ISO 2560:05	Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels. Classification
BS EN ISO 1461:09	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
BS 750:06	Specification for underground fire hydrants and surface box frames and covers
BS EN 60470:01	High-voltage alternating current contactors and contactor-based motor starters
BS 799:91	Oil burning equipment
BS EN 55014:06	Electromagnetic compatibility. Requirements for household appliances, electric tools and similar apparatus. Emission
BS EN 12620:02	Aggregates for concrete
BS 8442:06	Miscellaneous road traffic signs and devices. Requirements and test methods
BS EN 459-1:01	Building lime. Definitions, specifications and conformity criteria
BS EN	Nitriding steel. Technical delivery conditions

10085:01	
BS EN 10278:99	Dimensions and tolerances of bright steel products
BS EN 10089:02	Hot rolled steels for quenched and tempered springs. Technical delivery conditions
BS EN 10090:98	Valve steels and alloys for internal combustion engines
BS 1125:87	Specification for WC flushing cisterns (including dual flush cisterns and flush pipes)
BS 1188:74	Specification for ceramic wash basins and pedestals
BS EN 969:09	Ductile iron pipes, fittings, accessories and their joints for gas pipelines. Requirements and test methods
BS 1212-1:90	Float operated valves. Specification for piston type float operated valves (copper alloy body) (excluding floats)
BS EN 845-1:2003	Specification for ancillary components for masonry. Ties, tension straps, hangers and brackets
BS EN 13101:02	Steps for underground man entry chambers. Requirements, marking, testing and evaluation of conformity
BS 1363-2:95	13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets
BS 1377:90	Methods of test for soils for civil engineering purposes
BS EN 10255:04	Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions
BS EN 1982:08	Copper and copper alloys. Ingots and castings
BS 1428-D4:63	Microchemical apparatus. Volumetric analysis. Specification for capillary pipettes
BS EN 10149-2:96	Specification for hot-rolled flat products made of high yield strength steels for cold forming. Delivery conditions for thermomechanically rolled steels
BS EN 10149-3:96	Specification for hot-rolled flat products made of high yield strength steels for cold forming. Delivery conditions for normalized or normalized rolled steels
BS EN 1561:97	Founding. Grey cast irons
BS EN 485-2:08	Aluminum and aluminum alloys. Sheet, strip and plate. Mechanical properties
BS 1768:63	Specification for unified precision hexagon bolts, screws, & nuts (UNC & UNF threads). Normal series
BS EN 40:05	Lighting columns. Requirements for reinforced and prestressed concrete lighting columns
BS 1853:95	Tubular fluorescent lamps for general lighting service.
BS 1881	Methods for testing concrete
BS EN 10253-1:99	Butt-welding pipe fittings. Wrought carbon steel for general use and without specific inspection requirements
BS EN 1428:00	Methods of test for petroleum and its products. Bitumen and bituminous binders.
BS 2035:66/BS EN 969:09	Specification for cast iron flanged pipes and flanged fittings
BS EN 10052:94	Vocabulary of heat treatment terms for ferrous products
BS 2456:90	Specification for floats (plastics) for float operated valves for cold water services
BS EN 681-2:00	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers
BS 7956:00	Specification for primers for woodwork
BS 2752:03	Chloroprene rubber compounds. Specification

BS EN 60085:08	Electrical insulation. Thermal evaluation and designation
BS 2782-0:04	Methods of testing. Plastics. Introduction
BS EN 1563:97	Founding. Spheroidal graphite cast iron
BS EN 60921:04	Ballasts for tubular fluorescent lamps. Performance requirements
BS EN 1654:1998	Copper and copper alloys. Strip for springs and connectors
BS EN 1057:06	Copper and copper alloys. Seamless, round copper tubes for water and gas in sanitary and heating applications
BS EN 60099-1:94	Surge arresters. Non-linear resistor type gapped surge arrestors for a.c. systems
BS EN 10327:09	Continuously hot-dip coated steel flat products. Technical delivery conditions
BS EN 1011-1:09	Welding. Recommendations for welding of metallic materials. General guidance for arc welding
BS EN 1008:02	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete
BS EN 1947:02	Fire-fighting hoses. Semi-rigid delivery hoses and hose assemblies for pumps and vehicles
BS 3262-3:89	Hot-applied thermoplastic road marking materials. Specification for application of material to road surfaces
BS EN 14118-1:03	Reinforcement. Specifications for textile glass mats (chopped strand and continuous filament mats). Designation
BS EN ISO 1452-1:09	Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure. Unplasticized poly(vinyl chloride) (PVC U). General
BS 3506:69	Specification for unplasticized PVC pipe for industrial uses
BS 3532:90	Method of specifying unsaturated polyester resin systems
BS 3676-1:00/BS EN 60669-1:00	Switches for household and similar fixed-electrical installations. General requirements
BS EN 60188:01	High-pressure mercury vapour lamps. Performance specifications
BS 14020-1:02	Reinforcements. Specification for textile glass rovings. Designation
BS 3749:91	Specification for E glass fibre woven roving fabrics for the reinforcement of polyester and epoxy resins systems
BS EN 60898-1:03	Electrical accessories. Circuit breakers for overcurrent protection for household and similar installations. Circuit-breakers for a.c. operation
BS EN 593:04	Industrial valves. Metallic butterfly valves
BS 4027:96	Specification for sulfate-resisting Portland cement
BS 4108:06	Aerospace series. Wrenches, crow foot, attachment socket, socket drive
BS 4211:05	Specification for permanently fixed ladders
BS EN ISO 8501-1:2007	Preparation of steel substrates before application of paints and related products.
BS 4235-1:72	Specification for metric keys and keyways. Parallel and taper keys
BS EN 60309-2:99	Plugs, socket-outlets and couplers for industrial purposes. Dimensional interchangeability requirements for pin and contact-tube accessories

BS EN 10210-1:2006	Hot finished structural hollow sections of non-alloy and fine grain steels. Technical delivery requirements
BS 4999-147: 88	General requirements for rotating electrical machines. Specification for dimensions of brushes and brush-holders for electrical machinery
BS 4395:69	Specification for high strength friction grip bolts and associated nuts and washers for structural engineering. General grade
BS EN 13391: 04	Mechanical tests for post-tensioning systems
BS 4449:05	Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification
BS EN ISO 3766: 03	Construction drawings. Simplified representation of concrete reinforcement
BS 4482:05	Steel wire for the reinforcement of concrete products. Specification
BS 4483:05	Steel fabric for the reinforcement of concrete. Specification
BS 4486:80	Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete
BS EN 1092-1:07	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges
BS EN 1092-2:97	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges
BS EN 1092-3:03	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Copper alloy flanges
BS 4514:01	Unplasticized PVC soil and ventilating pipes of 82.4 mm minimum mean outside diameter, and fittings and accessories of 82.4 mm and of other sizes. Specification
BS EN 60598-1:2008	Luminaires. General requirements and tests
BS 4549-1:97	Guide to quality control requirements for reinforced plastics mouldings. Guide to the preparation of a scheme to control the quality of glass reinforced polyester mouldings
BS 4568-1:1970	Specification for steel conduit and fittings with metric threads of ISO form for electrical installations. Steel conduit, bends and couplers
BS 4592-1:06	Industrial type flooring and stair treads. Metal open bar gratings. Specification
BS 4607-1:84	Non-metallic conduits and fittings for electrical installations. Specification for fittings and components of insulating material
BS 4622:70	Specification for grey iron pipes and fittings
BS 4652:95	Specification for zinc-rich priming paint (organic media)
BS EN 1401-1:09	Plastic piping systems for non-pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS 4678-4:82	Cable trunking. Specification for cable trunking made of insulating material
BS EN 969:09	Ductile iron pipes, fittings, accessories and their joints for gas pipelines. Requirements and test methods
BS EN 60923:05	Auxiliaries for lamps. Ballasts for discharge lamps (excluding tubular fluorescent lamps). Performance requirements
BS 4800:89	Schedule of paint colors for building purposes
BS 10210-2:06	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties
BS EN 1514-1:97	Flanges and their joints. Dimensions of gaskets for PN-designated flanges. Non-metallic flat gaskets with or without inserts
BS 4872-1:82	Specification for approval testing of welders when welding procedure approval is not required. Fusion welding of steel
BS 4921:88	Specification for sherardized coatings on iron or steel

BS EN 60947-4-1:01	Low-voltage switchgear and control gear. Contactors and motor-starters. Electromechanical contactors and motor-starters
BS 4994:87/BS EN 13121-3: 08	GRP tanks and vessels for use above ground. Design and workmanship
BS 4999:04	General requirements for rotating electrical machines
BS EN 60079-1:07	Explosive atmospheres. Equipment protection by flameproof enclosures "d"
BS EN 1011-2:01	Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels
BS EN 1171:02	Industrial valves. Cast iron gate valves
BS EN 12334:01	Industrial valves. Cast iron check valves
BS EN 593:04	Industrial valves. Metallic butterfly valves
BS 5163-1:04	Valves for waterworks purposes. Predominantly key-operated cast iron gate valves. Code of practice
BS 5276-4:77	Pressure vessel details (dimensions). Standardized pressure vessels
BS EN 751-1:97	Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water. Anaerobic jointing compounds
BS 5306:09	Fire extinguishing installations and equipment on premises. Commissioning and maintenance of portable fire extinguishers. Code of practice
BS EN 1992-3:06	Eurocode 2. Design of concrete structures. Liquid retaining and containing structures
BS 5385-2:06	Wall and floor tiling. Design and installation of external ceramic and mosaic wall tiling in normal conditions. Code of practice
BS 5395-1:00	Stairs, ladders and walkways. Code of practice for the design, construction and maintenance of straight stairs and winders
BS EN 200:08	Sanitary tap ware. Single taps and combination taps for water supply systems of type 1 and type 2. General technical specification
BS EN 60947-3:09	Low-voltage switchgear and control gear. Switches, disconnectors, switch-disconnectors and fuse-combination units
BS EN 3-6:96	Portable fire extinguishers. Provisions for the attestation of conformity of portable fire extinguishers in accordance with EN 3 Part 1 to Part 5
BS 5472:77	Specification for low voltage switchgear and control gear for industrial use. Terminal marking and distinctive number. General rules
BS 5467:97	Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V
BS EN 14364:06	Plastics piping systems for drainage and sewerage with or without pressure. Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP). Specifications for pipes, fittings and joints
BS EN 61439-1:09	Low-voltage switchgear and control gear assemblies. General rules
BS EN 60529:92	Specification for degrees of protection provided by enclosures (IP code)
BS EN 37:99/BS EN 33:03	Pedestal W.C. pans with independent water supply. Connecting dimensions Pedestal W.C. pans with close-coupled flushing cistern. Connecting dimensions
BS ISO 3046-1:02	Reciprocating internal combustion engines. Performance. Declarations of power, fuel and lubricating oil consumptions, and test methods. Additional requirements for engines for general use

BS 5520:77	Specification for vitreous china bowl urinals (rimless type)
BS 5930:99	Code of practice for site investigations
BS EN 60947-1:07	Low-voltage switchgear and control gear. General rules
BS 6004:00	Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring
BS 6180:99	Barriers in and about buildings. Code of practice
BS EN 60702-1:02	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. Cables
BS 6266:02	Code of practice for fire protection for electronic equipment installations
BS 6346:97	Electric cables. PVC insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V
BS EN 60228:05	Conductors of insulated cables
BS 6500:00	Electric cables. Flexible cords rated up to 300/500 V, for use with appliances and equipment intended for domestic, office and similar environments
BS EN 62305-1: 06	Protection against lightning. General principles
BS EN 50214:06	Flat polyvinyl chloride sheathed flexible cables
BS EN 50241-1:99	Specification for open path apparatus for the detection of combustible or toxic gases and vapors. General requirements and test methods
BS 8215:91	Code of practice for design and installation of damp-proof courses in masonry construction
BS 7430:98	Code of practice for earthing
BS 7375:96	Code of practice for distribution of electricity on construction and building sites
BS EN 1537:00	Execution of special geotechnical work. Ground anchors
CP114	Structural Use of Reinforced Concrete in Buildings (Metric Units)
CP 116	The Structural Use of Precast Concrete

Federal Specifications

Fed Spec MMM-B-350A	Epoxy Concrete Adhesive
Fed Spec MMM-G-650A	Epoxy Bonding Agent
Fed Spec SS-A-701	Bituminous Protective Coating
Fed Spec TT-L-215	Raw Linseed Oil
Fed Spec TT-P-85	Paint, Reflectors etc.
Fed Spec TT-P-347	Chromium Oxide
Fed Spec TT-P-403	Magnesium Silicate
Fed Spec TT-P-442	Titanium Dioxide
Fed Spec TT-P-463	Zinc Oxide
Fed Spec TT-P-615	Basic Lead Silico – Chromate Primer
Fed Spec TT-P-641	Zinc Dust – Zinc Oxide Paint
Fed Spec TT-R-226	Alkyd Resin
Fed Spec TT-S-227E	Joint Sealer
Fed Spec TT-T-291	Mineral Spirits

Deutsche Industrie Norm (DIN)

DIN 1045	Reinforced Concrete Structures Design and Construction
DIN 1048	Regulations for Testing Concrete used During Erection of Concrete and Reinforced Concrete Structures (Water Tightness Test)
DIN 4125	Part 1 German Standard – Soil and Rock Anchors, and Part 2 Temporary Soil Anchors Analysis, Structural Design and Testing.

American Welding Society (AWS)

AWS A5.1, 5.17, 5.18 Welding Electrodes
AWS D2.0

International Electrotechnical Commission (IEC)

IEC 229	International Electro-technical Commission
IEC 265	High Voltage Switches
IEC 287	Electrical Cables
IEC 332	Part 2 International Electro-technical Commission
IEC 502	Extruded Solid Dielectrical Insulated Power Cables for Rated Voltages from 1 kV to 20 kV.
IEC 529	Classification of Degree of Protection Provided by Enclosures
IEC 662	International Electro-technical Commission

International Commission - Electrical Equipment

CEE 26 Rigid PVC Conduit and Fittings

U.S. Corps of Engineers Specifications (CRD)

C – 566 Grout

International Organization for Standardization (ISO)

ISO 160	Asbestos Cement Pressure Pipes (BS486)
ISO 7005	Pipeline Flanges for General Use
ISO 2531	Ductile Iron Pipes, Fittings and Accessories for Pressure Pipelines

British Institution of Electrical Engineers

IEE Regulations

American Concrete Institute (ACI)

ACI 315	Manual of Standard Practice for Detailing Reinforced Concrete Structures
ACI 347	Formwork Design
ACI MCP	Manual of Concrete Practice, Parts 1 and 2

American Wood Preservers' Association (AWPA)

C1, C14 Timber Treatment

Kuwait Standard Specification

21 Manhole Covers and Frames

Kuwait Manual on Uniform Traffic Control Devices

Federal Test Method Standard

141 Paint, Varnish, Lacquer and related Materials. Method of Inspection, Sampling and Testing.

Ministry of Public Works (MPW)

- Standard Test Procedure for Measuring Stripping and Heat Stability on Bitumen-Aggregate Mixtures in the Presence of Water.
- Test Procedures for Detection of Hydrated Lime or Cement in Loose Asphalt Mixes or Cores.
- Test for Soft and Friable Particles (Mesh).

Asphalt Institute

MS-2 Marshall Method of Mix Design

Porcelain Enamel Institute Inc.

ALS – 105

British Heating and Ventilating Contractors Association

DW/142

Oil Companies Materials Association, London

DFCP 4

British Chartered Institution of Building Services

Commissioning Codes A, C, R and W

Boeing Specification Support Standards

Institution of Public Lighting Engineers (IPLE)

Technical Report No. 4

Technical Report No. 7 – High Mast Lighting

ESI – Electricity Supply Industry Standards (UK)

American Water Works Association (AWWA)

AWWA C 104	ANSI Standard for Cement Water Lining for Ductile Iron and Grey Iron Pipes and Fitting for Water.
AWWA C 105	ANSI Standard for Polyethelene Encasement for Grey and Ductile Iron Piping for Water and Other Liquids
AWWA C 504	Rubber Seating Butterfly Valves.
AWWA C 651	Disinfecting Water Mains.

American Petroleum Institute (API)

API 5LS	Specification for Spiral-Weld Line Pipe
API 6D	Pipeline Valves and Enclosures, Connectors and Swivels
API 1104	Welding Pipelines and Related Facilities.

American Standards Association (ASA)

B 16.5	Pipe Flanges and Flanged fittings Steel Nickel Alloy and other Special Alloys.

Building Research Establishment (BRE) UK

BRE Digest 35 Shrinkage of Natural Aggregates in Concrete

American National Bureau of Standards

Units for Colour

"Kuwait Labour Laws" (in English language)

Standards for Prepared Planting Medium

The following codes, standards and publications will be used for Prepared Planting Medium as specified in these Specifications.

USA Federal Specification

O-F-241D Fertilizer, Mixed Commercial
O-P-166E Peat, Moss, Humus, and Peat, Reed-sedge.

American National Standards Institute (ANSI)

Z60 1 Nursery Stock.

Publications

American Joint Committee on Horticultural Nomenclature

(AJCHN) Second Edition 1942, Standardized Plant Names

New Western Garden Book Edited by Sunset Books, ISBN 0-376-03889-6

Florida, USA Department of Agriculture and Consumer Services

Division of Plant Industry Publications "Grade and Standards for Nursery Trees" – Part II – Palms and Trees

Association of Official Analytical Chemists (AOAC)

Official Methods of Analysis

1000.02 LABORATORY INSTANTIATION

A well-staffed, well-established environment (i.e., capacity and the capability) is essential to providing Lab core services and functions in an efficient and effective manner. This Section details the minimum requirements for instantiating a laboratory environment including staffing and their roles, responsibilities and qualifications.

Each laboratory should have a minimum number of staffs having different kind of responsibilities as below; Laboratory Director, Laboratory Team Leader, Laboratory engineers, Material Engineer and Other Staffs for helping in the laboratory works.

The Material Engineer is responsible for the overall operation of the Lab, which includes oversight of evaluation and quality assurance. The Material Engineer 's responsibilities include: (a) Set the daily goals for the lab, (b) Ensure all Lab operations adhere to the security and confidentiality requirements, (c) Make efficient, effective use of the Lab's staff and other resources, (d) Ensure all evaluation activities are consistent with the Lab Spec, (e) Appoint roles and delegating responsibilities, (f) Authorize submission of the Evaluation Report to the Approval Authority, (g) Prioritize evaluation and other day-to-day Lab tasks, (h) Assign resources and staffs for conducting tests, (i) Communicate with the Suppliers, (j) Provide Evaluation Reports to the Lab Director, (k) Supervising and conducting the laboratory tests in systematic way.

Lab engineers execute the day-to-day tasks of the Lab. Lab engineer responsibilities include: (a) Perform tests, (b) Document test results, (c) Provide technical expertise.

There should be some lab assistants who will help in conducting the laboratory tests.

The Staffs will be hired either by the Contractor or by the Consultants as per the requirements. The minimum qualification of the staffs will be decided from the Consultant's side as per the project requirement.

1000.03 RULES OF BEHAVIOUR

The Material Engineer makes readily available to all Lab staff a set of rules that describes their responsibilities and expected behavior regarding all facets of the Lab. Every Lab staff member (employee and contractor) must provide a signed acknowledgement that they have read, understand, and agree to abide by the rules of behaviour. This must be done before any Lab activity is undertaken.

1000.04 TYPES OF LABORATORIES

This specification details three separate Types of Site Laboratories as follows:

"Type A" - Soils and Concrete Laboratory

“Type B” - Asphalt Laboratory

“Type C” - Asphalt, Soils and Concrete Laboratory

The type and number of laboratories to be provided shall be as designated in the Contract Documents.

Where a “Type C” Laboratory is required, the Engineer may approve two separate laboratories provided the total requirements of a “Type C” Laboratory are met.

1000.05 EQUIPMENT FOR SAMPLING

The Contractor at his cost shall provide the equipment, operators and safe suitable facilities as required for the Engineer to obtain samples.

1000.06 USE OF LABORATORY

The Engineer shall have the exclusive use of the laboratory at all times during the Contract Period. The laboratory provided shall not be used for other Contracts without the written permission of the Engineer.

The Contractor shall supply his own laboratory and shall not utilize the Engineer’s Site Laboratory.

1000.07 LOCATION OF THE LABORATORY

The location of the laboratory shall be as designated by the Engineer. The laboratory shall not be removed from the project until the Contractor is instructed in writing by the Engineer.

1000.08 MAINTENANCE OF THE LABORATORY

The Contractor shall at all times be responsible for maintaining the building, utilities and all testing equipment in a satisfactory condition for use. The Contractor shall provide replacement equipment where required by the Engineer whilst equipment is being repaired. Disposable supplies such as filter paper, trichloroethylene, Speedy Moisture, Reagent, S.E. Stock Solution, etc. shall at all times be kept replenished so as to prevent testing delays.

The Contractor shall also include for routine maintenance of the facilities which shall include, but not be limited to, daily dusting, cleaning and janitorial work; window washing and wet floor mopping; as necessary maintenance and repair to mechanical, air-conditioning, heating, electrical and plumbing systems; providing potable drinking water and toilet supplies; disposal of all waste, maintenance of interior and exterior of building, grounds and paved areas, and including any repairs thereto. Maintenance shall also include providing water, gas, electricity, and local telephone services, and any other maintenance or service as specified herein or as further directed by the Engineer.

Maintenance work by the Contractor shall be generally scheduled outside of the normal working hours of the Engineer and as directed by the Engineer.

The Contractor shall be responsible for and pay all charges, fees or other expenses for maintaining water, gas and electric service, telephone service, and other utilities during the construction under this Contract. At the completion of the project, the Contractor shall retain possession of the laboratory and equipment, unless otherwise noted in the Contract Documents.

1000.09 APPROVAL OF LABORATORY

The Contractor shall complete the Engineer’s Site Laboratory Facility to the satisfaction of the Engineer within 15 days of the Date of receipt of the Order to Commence. Prior to acceptance of the Laboratory building and of the equipment, the Engineer shall inspect the said building and equipment for compliance with those specifications. If the Engineer is satisfied that the building and equipment are in compliance with the Specification he shall issue a letter of acceptance of the overall facility.

Should the Contractor fail to complete the Engineer’s Site Laboratory Facility he shall incur a penalty of Kuwaiti Dinars Two Hundred (KD 200/-) per day until the Engineer’s Site Laboratory Facility is completed to the Engineer’s satisfaction.

The Contractor shall order all the required equipment for the site Laboratory within 45 days of signing the Contract and shall provide documentary evidence of having placed the necessary orders. Should the Contractor

fail to order the equipment within the specified time period or fail to provide the required evidence of placing the orders, he shall incur a penalty of Kuwaiti Dinars Two Hundred and Fifty (KD 250/-) per day until the required equipment is ordered or the documentary evidence provided. This penalty is in addition to that for failure to complete the Engineer's Site Laboratory Facility on time.

Further, if the Contractor fails to order any of the required equipment within the specified period, the Engineer reserves the right after 15 days of receipt by the Contractor the Order to commence to carry out any laboratory testing requiring such equipment in any other laboratory designated by the Engineer with any fees and charges to be deducted from any amounts due to the Contractor.

Should the Contractor fail to comply with the Specifications at any time during the Contract Period, the Engineer may order any or all of the following:

a. Stoppage of all work until the Specifications have been complied with.

b. Stoppage of any portion or phase of the work until the Specifications have been complied with.

c. Sampling and testing to be performed at any other laboratory designated by the Engineer with such fees and charges to be deducted from any amounts due to the Contractor.

1000.10 MEASUREMENT AND PAYMENT FOR SITE LABORATORIES

No separate measurement or payment shall be made for Site Laboratories and associated Temporary Buildings, but they shall be considered as subsidiary work, the cost of which shall be deemed to be included in the Contractor's overall price.

1001 - "TYPE A" SOILS AND CONCRETE LABORATORY

1001.01 GENERAL REQUIREMENTS

A "Type A" Soils and Concrete Laboratory shall comply with the minimum requirements set forth herein. The laboratory shall contain all of the specified equipment in acceptable working condition and adequate storage and working spaces for the following:

a. Sample preparation for soils, aggregates, etc.

b. Storage of field sampling equipment, i.e. sand cone, density apparatus, aggregate stockpile sampling tools, concrete cube/cylinder moulds, cement and soil sampling tools, etc.

c. Soil and aggregate testing: Gradation, L.L. P.I., Sand Equivalent, Proctor, abrasion, soundness, organic content, Aggregate Flakiness and Elongation, Calibration of Sand for Density-testing, Speedy Moisture, Oven Moisture, C.B.R., Chemical testing, etc.

d. Concrete testing: Making and curing concrete cubes, slump, air content, unit weight, temperature, compressive strength, etc.

1001.02 BUILDING AND UTILITIES REQUIREMENTS

A "Type A" Soils and Concrete Laboratory shall have a minimum internal floor area of 85 square meters, exclusive of tables, benches and partitions. The laboratory shall be provided with 240 volt 50 Hz electricity and enough outlets shall be provided to accommodate the required testing equipment; with lighting meeting the approval of the Engineer; with a minimum of 2 No. air conditioners and heating system capable of maintaining a constant temperature of 20° Centigrade all the year round; adequate water storage and pressure for normal testing; minimum of 2 sinks with faucets to accommodate wash gradations; generator for use when electricity is not available; rigid flooring adequate to support operating test equipment without vibration, dustproof covers for all balances; wall thermometer, etc. A minimum of 10 meters of work benches, 900 mm high by 750 mm wide shall be provided and arranged in an acceptable manner. These work benches should have tops covered with an approved plastic laminate or tin sheet, shall contain adjustable shelves and drawers and shall be constructed of 19 mm plywood. A minimum of 8 meters of cupboards shall be constructed approximately 600 mm above the work benches. These cupboards shall have a minimum of two 450 mm high shelves approximately 300 mm wide. All cupboards shall be provided with doors. The laboratory shall have a minimum of two exhaust fans and three

opening windows with blinds and insect screens.

The laboratory shall be provided with two double entrance doors arranged so as to provide protection against outside elements and wide enough to unload materials from site vehicles into the laboratory. A minimum clear opening of 2 meters shall be provided, together with a ramp to accommodate the difference in level from the floor level to the outside level.

Prior to constructing the laboratory, the Contractor shall obtain written approval from the Engineer for his proposed construction and arrangement of the laboratory.

1001.03 EQUIPMENT REQUIREMENTS

A “Type A” Laboratory shall contain as a minimum, the equipment and supplies shown herein. . All specified laboratory equipment shall be new when supplied and, within the descriptions given below, shall be of a type and from a manufacturer approved by the Engineer.

The Contractor shall be responsible for providing labour for the stripping, cleaning and reassembly of the cube/cylinder moulds.

Periodical calibration of all testing equipment shall be carried out, to the approval of the Engineer.

Item No.	Description	Quantity
1.	Speedy moisture tester large size	6
2.	Multipurpose field scale 25 kg x 1 g	3
3.	Moisture tester reagent (1 carton)	24 cans
4.	Cement Pans tapered 610 mm x 610 mm x 63 mm	12
5.	Trowel triangular blade 180 mm long	6
6.	Trowel rectangular blade 280 mm x 115 mm	3
7.	150 mm cube form with base plate, or	100
	150 mm diameter cylinders	100
8.	Sieve, brass 8" diameter full height:	
	a. Sieve opening 2" (50 mm)	2
	b. Sieve opening 1 1/2" (37.5 mm)	2
	c. Sieve opening 1" (25 mm)	2
	d. Sieve opening 3/4" (19 mm)	2
	e. Sieve opening 1/2" (12.5 mm)	2
	f. Sieve opening 3/8" (9.5 mm)	2
	g. Sieve opening 1/4" (6.35 mm)	2
	h. Sieve mesh No. 4 (4.75 mm)	2
	i. Sieve mesh No. 8 (2.36 mm)	2
	j. Sieve mesh No. 10 (2.00 mm)	2
	k. Sieve mesh No. 16 (1.18 mm)	2
	l. Sieve mesh No. 30 (0.600 mm)	2
	m. Sieve mesh No. 40 (0.425 mm)	2
	n. Sieve mesh No. 50 (0.300 mm)	2
	o. Sieve mesh No. 100 (0.150 mm)	2
	p. Sieve mesh No. 200 (0.075 mm)	6
9.	Brass pan for above	4
10.	Brass cover with ring	4
11.	Brass riddle Sieves, 18" diameter :	
	a. Sieve opening 2" (50 mm)	1

	b. Sieve opening 1 1/2" (37.5 mm)	1
	c. Sieve opening 1" (25 mm)	1
	d. Sieve opening 3/4" (19 mm)	1
	e. Sieve opening 1/2" (12.5 mm)	1
	f. Sieve opening 3/8" (9.5 mm)	1
	g. Sieve opening mesh No. 4 (4.75 mm)	1
12.	Quartering canvas	4
13.	Rotap sieve shaker, 240 V. 50 cycles	1
14.	Large capacity Gibson sample splitter with hopper	1
15.	a. Sample bags, plastic lined approx. size 900 x 500 mm	1000
	b. Sample bags, paper lined approx. size 900 x 500 mm	1000
16.	Aggregate scoop pans	2
17.	Wet washing sieves 200 (0.075mm) mesh	6
18.	Sample splitter, stainless steel, 1/2 “ (12.5 mm) chute	1
19.	Timing device 0-60 minutes	2
20.	Fine sieve brush	6
21.	Wire sieve brush	6
22.	Tamping Rod, 600 mm long 16mm diameter	4
23.	Yield bucket 3 dm 3 (1/10 ft3)	1
24.	Yield bucket 30 dm 3 (1 ft3)	2
25.	Slump Test Set	4
26.	Unit Weight bucket 15 dm3 (1/2 ft3)	1
27.	Mixing bowls stainless steel, 2 litre cap	12
28.	Pans, stainless steel, rectangular	12
29.	Cement, mould brush, brass	3
30.	Automatic combination compression tester (150,000 kg)	1
31.	Mortar cube mould	4 (12
32.	Mini slump cone (as developed by the Portland Cement Association, USA)	1 set
33.	Quality of water test kit	1
34.	Armoured Concrete thermometers	10
35.	Hot plate 220/240 V, 50 Hz	4
36.	Double wall gravity convection oven 220/240 V, 50 Hz	2
37.	Laboratory batch oven 220-240 V 50Hz	1
38.	Dial-O-Gram balance 310 x 10 mg	1
39.	Triple beam scale	1
40.	Triple beam scale 2610 x 100 mg with scoop	1
41.	Mettler precision balance (Model P-10)	1
42.	Mettler precision balance 4 kg x 100 mg	1
43.	Platform beam scale capacity, 100 kg	1

44.	Aggregates specific gravity set for fine aggregate	1
45.	Density basket for coarse aggregate	1
46.	Liquid limit device to ASTM D4318 with counter	2
47.	ASTM grooving tool	2
48.	Spare cups for liquid limit device	4
49.	Porcelain mixing dish	6
50.	100 ml Graduated cylinder	6
51.	25 ml Graduated Cylinder	3
52.	500 ml Graduated cylinder	3
53.	Flexible spatula	6
54.	Plastic limit plates	3
55.	Soil mortar	2
56.	Soil pestle	2
57.	Sand equivalent test set (*without shaker)	2
58.	Sand equivalent stock solution	15 bot
59.	Aspirator jar 5 litre capacity	2
60.	Modified compaction mould 150 mm (6”) dia	2
61.	Modified compaction mould 100 mm (4”) dia	2
62.	Modified compaction hammer	2
63.	Sample ejector	1
64.	Straight edge	6
65.	Density pick	4
66.	Chisel	4
67.	Rubber Mallet	4
68.	Sampling spoons	6
69.	Sand density cone	3
70	Top Hat Calibration, complete	1
71.	Field density plate	6
72.	Replacement jugs, 4.5L (1 gallon) size	12
73.	Density sand	1000 kg
74.	Moisture tins, 85 ml (3 oz) capacity	50
75.	Moisture tins, 170 ml (6 oz) capacity	50
76.	Heat insulating gloves	6 pairs
77.	Laboratory tongs	3
78.	Stopwatch	2
79.	Sample cans, 10 dm3	60
80.	Sample cans, 1 dm3	60
81.	Spatula 150 mm long blade x 25 mm wide	6
82.	Large scoop	2
83.	Large pick and handle	4
84.	Shovel square edge	4
85.	Soil auger 150 mm	1
86.	Extra head	1
87.	25 mm Square tamping bar for 150 mm	4
88.	Mechanical loading press, 4000 kg	1

89.	CBR Moulds (inside diameter: 152.4 mm, height: 177.8 mm) with perforated base.	15
90.	Spacer disc 150 mm (5-15/16") diameter, 61.4 mm (2.416" high)	2
91.	Dial Indicator	4
92	Swell plate	15
93.	Tripod attachment	3
94.	Surcharge weigh, 2.3 kg (5 lb) annular disc	24
95.	Surcharge weight, 2.3 kg (51 lb) slotted	24
96.	Filter papers for CBR test moulds	20 boxes
97.	Volumes 1 and 2 of AASHTO Specifications	1 set
98.	Flakiness plate (BS 812)	2
99.	Elongation gauge (BS 812)	1
100.	Galvanised steel tank for curing concrete specimens, 3 m3, with stand	2
101.	Wheelbarrow	3
102.	350 mm dia x 450 mm deep plastic dustbins	6
103.	Electronic calculator, scientific multi-function with memory and statistical functions	4
104.	Maximum/minimum thermometer	2
105.	Wire gauze asbestos disc for use on hot	6
106.	Surface coating thickness gauge (paint) Elcometer	1
107.	Sieve shaker for 18" (457 mm) sieves 220/240 V50 Hz with circular and vertical movement non tapping	1
108.	Sand Equivalent Shaker 240-220 V 50 Hz with timer	1
109.	Automatic Compactor for Protector and CBR soil compaction tests	1
110.	Tank for soaking CBR, samples and for determining weight of immersed materials min size 1000 mm x 600 mm x 600 mm	1
111.	DIN percussion type Dutch Cone Penetration Apparatus – hand operated	1
112.	Frequency gauge for checking concrete vibrators	1
113.	Other miscellaneous equipment in the quantities necessary to perform the required tests should also be supplied	
114.	Tool kit comprising screwdrivers 2 No. large, 2 No. small, electrical screwdrivers (circuit testing), 2 pairs of pliers 2 No. 450 mm stilson wrenches, adjustable spanners – self grip wrench, hacksaw and blades smooth and bastard files electric soldering iron, flux and solder; 2 No. clawhammer; panel saw, range of open ended and ring spanners (metric and ANF inch sizes)	1 set
115.	Wind velocity gauge	1
116.	Mason Hygrometer	1

117.	Table mounted disc saw for masonry and rock, electric powered, with replacement discs as required.	1
118.	Laboratory portable concrete mixer-drum type 110 litre 75 hp/220 V/ 50 cy/1 ph	1
119.	100 mm Cube form with base plate	12
120.	Oedometer	1
121.	Permeability Testing Machine (Falling Head and Constant Head)	1
122.	Compressive strength and young modulus testing machine	1
123.	Nuclear density measurement apparatus	1
124.	Los Angeles Abrasion equipment	1
125.	Soundness testing Equipment	1

NB: All consumable items are to be replenished as needs dictate.

1002 - "TYPE B" ASPHALT LABORATORY

1002.01 GENERAL REQUIREMENTS

A "Type B" Asphalt Laboratory shall comply with the minimum requirements set forth herein. The laboratory shall contain all of the specified equipment in acceptable working order and adequate storage and working spaces for the following:

a. Sample preparation of asphalt mixes, aggregates, etc.

b. Storage of field sampling equipment

c. Testing of asphalt mix aggregates: Flakiness, Elongation, Gradation, Sand Equivalent, Los Angeles Abrasion, Soundness, etc.

d. Testing of asphalt mixes: Density of compacted samples, Extraction Graduation, Bitumenometer Ash Correction, Aggregate Specific Gravity, Compaction of Marshall Moulds, Stripping potential, Moisture Induced damage, Marshall Mix, Superpave testing including compatibility testing, penetration, softening point, viscosity, flash point, Dynamic Shear , RTFO Mass Loss , Elastic Recovery , Pressure Aging Vessel temperature, Creep Stiffness, etc.

1002.02 BUILDING AND UTILITIES REQUIREMENTS

A "Type B" Asphalt Laboratory shall have a minimum internal floor area of 75 square meters, exclusive of tables, benches and partitions. The laboratory shall be provided with 240 volt 50 Hz electricity and enough outlets shall be provided to accommodate the required testing equipment; with lighting meeting the approval of the Engineer; with a minimum of 2 No. air conditioners and a heating system capable of maintaining a constant room temperature of 20^{o} Centigrade all year round; adequate water storage and pressure for normal testing; small inside storage tank; tank for trichloroethylene; minimum of 2 sinks including faucet connections for 4 reflux extractors plus wash gradations, etc., generator for use when electricity is not available; rigid flooring adequate to support operating test equipment without vibration; dustproof covers for all balances; wall thermometer etc. A minimum of eight meters of work benches, 900 mm high by 750 mm wide, shall be provided and arranged in an acceptable manner. These work benches should have tops covered with an approved plastic laminate or tin sheet, shall contain adjustable shelves and drawers and should be constructed of 19 mm plywood. A minimum of 8 meters of cupboards shall be constructed from approximately 600 mm above the work benches. These cupboards should have a minimum of two 450 mm high shelves approximately 300 mm wide. All cupboards shall be provided with doors. The laboratory shall have a minimum of 2 exhaust fans and three opening windows with blinds and insect screens.

The Laboratory shall be provided with two double entrance doors arranged so as to provide protection against outside elements and wide enough to unload materials from site vehicles into the laboratory. A minimum clear

opening of 2 meters shall be provided. Together with a ramp to accommodate the difference between the internal floor level and the outside level.

Prior to constructing the laboratory, the Contractor shall obtain written approval from the Engineer for his proposed construction and arrangement of the laboratory.

1002.03 EQUIPMENT REQUIREMENTS

A "Type B" Laboratory shall contain as a minimum, the equipment and supplies shown herein. All specified laboratory equipment shall be new when supplied and, within the descriptions given below, shall be of a type and from a manufacturer approved by the Engineer.

Where called for in the Contract Documents, the range of equipment required for the Modified Marshall method mentioned in AI MS-2 for aggregate larger than 25.4mm shall be provided in addition to the equipment listed in this Section.

Item No.	Description	Quantity
1.	Tongs	2
2.	Heat insulating gloves	6 Pairs
3.	Hot plate (220/240 V, 50 Hz)	2
4.	Marshall compaction moulds	12
5.	Dial thermometers	6
6.	Specific gravity set for fine aggregate	2
7.	Wire basket, galvanised, for specific gravity	2
8.	Bowls stainless steel 2 litre cap.	10
9.	Trays, galvanised 18" x 18" x 3"(457 mm x 457 mm x 76 mm)	3
10.	Reflux extractor, glass 4000 g cap.	2
11.	Filter papers for above	80 packs
12.	Spare glass jars for above	10
13.	Centrifuge extractor, 3000 g cap	2
14.	Bowl for above, 3000 g cap	2
15.	Nickel evaporating dish	5
16.	Bunsen burners	2
17.	Glass bituminometre 750 ml.	5
18.	Glass bituminometre 1500 ml.	5
19.	Thermostatic refrigerated water bath at least 150 mm deep with temperature control ($25^{o}C \pm 1/2^{o}C$) for use with bituminometer	
20.	Double Wall Gravity Convection (220/240V 50 HZ)	1
21.	Laboratory batch oven 220/240V50Hz	1
22.	Thermostatic water bath at least 150 mm deep with temperature control ($60^{o}C \pm 1/2^{o}C$) and fitted with shelf for supporting Marshall stability specimen 50 cm from Bottom of tank	1
23.	Mechanical mixer with capacity of 2 kg and a mixing bowl surrounded by aheating element with a suitable control	1
24.	Marshall Asphalt Stability Test Set Complete (220/240V, 50 Hz)	1

25.	Large scoop	2
26.	Sampling spoons	3
27.	Balance, Mettler, electrical P-10	1
28.	Mettler precision balance 4 kg x 100 mg and 10	
29.	Sample ejector	1
30.	Bitumen sampler (Bacon device)	2
31.	Rotap sieve shaker 220/240 V, 50 Hz	1
32.	Balance, triple beam	1
33.	Brass pan, 2” deep	4
34.	Brass cover with ring	4
35.	Sieves, Brass, 8" dia full height :	
	a. Sieve opening 2" (50 mm)	3
	b. Sieve opening 1 1/2" (37.5 mm)	3
	c. Sieve opening 1" (25 mm)	3
	d. Sieve opening 3/4" (19 mm)	3
	e. Sieve opening 1/2" (12.5 mm)	2
	f. Sieve opening 3/8" (9.5 mm)	2
	g. Sieve mesh No. 4 (4.75 mm)	2
	h. Sieve mesh No. 8 (2.36 mm)	2
	i. Sieve mesh No. 16 (1.18 mm)	2
	j. Sieve mesh No. 30 (0.600 mm)	2
	k. Sieve mesh No. 50 (0.300 mm)	2
	l. Sieve mesh No. 100 (0.150 mm)	2
	m. Sieve mesh No. 200 (0.075 mm)	4
36.	Brass riddle sieves, 18" diameter :	
	a. 2" opening (50 mm)	1
	b. 11/2" opening (37.5 mm)	1
	c. 1" opening (25 mm)	1
	d. 3/4" opening (19 mm)	1
	e. 1/2" opening (12.5 mm)	1
	f. 3/8" opening (9.5 mm)	1
	g. Sieve mesh No. 4 (4.75 mm)	1
37.	Wet washing sieve, 200 mesh	4
38.	Sample splitter, large, Gibson	1
39.	Sample splitter, Riffler, stainless steel	1
40.	Sample splitter, Riffler, 12.5 mm chute	1
41.	Quartering canvas	4
42.	Sample bags, plastic lined 900 x 500 mm	1000
43.	Sample bags, paper lined 900 x 500 mm	1000
44.	Tube Sampler	2
45.	Sampling cans, 10 dm3 capacity	50
46.	Sampling cans, 1 dm3 capacity	50
47.	Sand equivalent test set (*without shaker)	2
48.	Sand equivalent stock solution	20 bots
49.	Wide mouth, clear glass bottles, 60 ml (2 oz) capacity, screw-on-cap	12 bots
50.	Standard density sand	1000 kg
51.	Double graduated cylinders, 100 ml.	3
52.	Double graduated cylinders, 1 litre	3
53.	Aluminum beakers, 500 ml.	6
54.	Spatula, flexible	4

55.	Square tipped shovel	2
56.	Mixing trowel	3
57.	Fine sieve brush	6
58.	Wire sieve brush	6
59.	Timing devices 0-60 minutes	3
60.	Thermometre 18-28 degrees C range	3
61.	Pocket type thermometers 0-250 degrees C	3
62.	Weights, stainless steel :	
	a) 20 kg.	30
	b) 10 kg.	4
	c) 5 kg.	4
	d) 1 kg.	4
63.	Tape measure (3 metres)	3
64.	Tape measure (5 metres)	3
65.	Funnel, 300 mm diameter	3
66.	Funnel, 150 mm diameter	3
67.	Funnel, 75 mm diameter	3
68.	Tripod stands	3
69.	Platform scale - 250 kg x 100 g. (eg. Avery Model 32054 BA)	1
70.	Insulated box - 300mm x 300mm x 300mm	3
71.	Aspirator jar, 5 Litre capacity	3
72.	Trichloroethylene	400 litres
73.	Flakiness plate (B.S.812)	2
74.	Elongation gauge (B.S.812) graduated in 0.1 ml. divisions	1
75.	Speedy Moisture Tester	1
76.	Speedy Moisture Reagent	24 cans
77.	Volume 1 and 2 of AASHO Specifications	1 set
78.	Measuring cups, Pyrex glass, graduated in 10 ml divisions	2
79.	5 ml. or 10 ml. Glass hypodermic syringe (as used for injections)	2
80.	Beakers, Pyrex glass, 500 ml. cap	6
81.	Dropping bottles TK pattern, 100 ml.	4
82.	Supply of distilled water	
83.	Phenolphthalein indicator	100 g
84.	Ethyl alcohol absolute	2.5 litres
85.	Supply of unleaded kerosene	
86.	Hydrochloric acid analar	2.5 litres
87.	Hi Lo Detector, 4 m with attachments	1
88.	4 m straight edge and wedge device for measuring surface irregularity	2
89.	Electronic Calculator, scientific multi-function with memory and statistical functions	4
90.	Max/Min. thermometer	2
91.	Wire gauze asbestos discs for use on hot plates	6
92.	Surface coating thickness gauge (paint) Elcometer	1
93.	Rubber Tubing 12.7 mm bore	6 m

94.	Rubber Tubing 6 mm bore x 12 mm OD	6 m
95.	Wheelbarrow	3
96.	350 mm dia. X 450 mm deep plastic Dustbin	6
97.	Sieve shaker for 18" (457 mm) sieves, 220-240V 50 Hz with circular and vertical movement non-tapping	1
98.	Sand Equivalent Shaker 220-240V 50 Hz with timer	1
99.	Automatic compactor for asphalt compaction with facility to automatically rotate sample during compaction 220-240V 50 Hz	1
100.	Standard Penetrometer complete with penetration needles.	1
101.	Softening Point Apparatus complete plus attachments	1
102.	Purpose built fume cupboard with extraction system for use in asphalt analysis	1
103.	Exterior covered storage area for solvents for asphalt analysis including feed and tap system to the interior of the laboratory	1
104.	Other miscellaneous equipment in the quantities necessary to perform the required tests should also be supplied.	
105.	Tool kit comprising-screwdrivers 2 No. large, 2 No. small electrical screwdrivers (circuit testing), 2 pairs of pliers, 2 No. 450 mm stilson wrenches, adjustable spanners – self grip wrench; hacksaw and blades; smooth and bastard files; electric soldering iron, flux and solder; 2 No. clawhammer; panel saw, range of open ended and ring spanners (metric and ANF inch sizes)	1 set
106.	Coring Drill	1
107.	Core Cutting Machine	1
108.	Table mounted disc saw for masonry and rock, electric powered, with replacement discs as required	1
109.	Los Angeles Abrasion Testing Equipment	1
110.	Soundness Testing Equipment	1
111.	Rolling Thin Film Oven	1
112.	Pressure Aging Vessel	1
113.	Dynamic Shear Rheometer	1
114.	Rotational Viscometer	1
115.	Bending beam Rheometer	1
116.	Direct Tension Tester	1

NB: All consumable items are to be replenished as needs dictate.

1003 - "TYPE C" ASPHALT, SOILS AND CONCRETE LABORATORY

1003.01 GENERAL REQUIREMENTS

A "Type C" Asphalt, Soils and Concrete Laboratory shall comply with the minimum requirements set forth herein. The laboratory shall contain all of the specified equipment in acceptable working order and adequate storage

and working spaces for the following:

a. Preparation of soil, aggregate and asphalt mix samples etc.

b. Storage of field sampling equipment, i.e. Sand cone, Density Apparatus, Stockpile Sampling Tools, Concrete Cube/Cylinder Moulds, Cement, Bitumen and Soil Sampling Equipment, etc.

c. Soil and aggregate testing: Gradation, L.L. P.I., Sand Equivalent, Proctor, abrasion, soundness, organic content, Aggregate Flakiness and Elongation, Calibration of Sand for Density-testing, Speedy Moisture, Oven Moisture, C.B.R., Chemical testing, etc.

d. Concrete Testing: Making and curing concrete cubes, compressive strength testing, slump, air content, temperature, unit weight etc.

e. Asphalt Mix Testing: Density of compacted samples, Extraction Graduation, Bitumenometer Ash Correction, Aggregate Specific Gravity, Compaction of Marshall Moulds, Stripping potential, Moisture Induced damage, Marshall Mix, Superpave testing including compatibility testing, penetration, softening point, viscosity, flash point, Dynamic Shear , RTFO Mass Loss , Elastic Recovery , Pressure Aging Vessel temperature, Creep Stiffness, etc.

1003.02 BUILDING AND UTILITIES REQUIREMENTS

A 'Type C' Asphalt, Soils and Concrete Laboratory shall have a minimum internal floor area of 110 square metres, exclusive of tables, benches and partitions. The laboratory shall be provided with 240 volt, 50 Hz. electricity and enough outlets shall be provided to accommodate the required testing equipment; with lighting meeting the approval of the Engineer; with a minimum of 2 No air conditioners and heating system to capable of maintaining a constant temperature of 20^{o}C all year round; adequate water storage and pressure for normal testing; small inside storage tank for trichloroethylene; minimum of 2 sinks including faucet connections for 4 reflux extractors plus wash gradations, etc.; rigid flooring adequate to support operating test equipment without vibration; dustproof covers for all balances; wall thermometer etc., a minimum of 12 metres of work benches, 900 mm high by 750 mm wide shall be provided and arranged in an acceptable manner.

These work benches should have tops covered with an approved plastic laminate or tin sheet, shall contain adjustable shelves and drawers and shall be constructed of 19 mm plywood. A minimum of 10 metres of cupboards shall be constructed approximately 600 mm above the work benches. These cupboards shall have a minimum of two 450 mm high shelves approximately 300 mm wide. All cupboards should be provided with doors. The laboratory shall have a minimum of two exhaust fans and three opening windows with blinds and insect screens.

The laboratory shall be provided with two double entrance doors arranged so as to provide protection against outside elements and wide enough to unload materials from site vehicles into the laboratory. A minimum clear opening of 2 metres shall be provided, together with a ramp to accommodate the difference in level from the floor level to the outside level.

Prior to constructing the laboratory, the Contractor shall obtain written approval from the Engineer for his proposed construction and arrangement for the laboratory.

1003.03 EQUIPMENT REQUIREMENTS

A "Type C" laboratory shall contain as a minimum, the equipment and supplies shown herein. . All specified laboratory equipment shall be new when supplied and, within the descriptions given below, shall be of a type and from a manufacturer approved by the Engineer.

Where called for in the Contract Documents, the range of equipment required for the Modified Marshall method mentioned in AI MS-2 for aggregate larger than 25.4mm shall be provided in addition to the equipment listed in this Section.

The Contractor shall be responsible for providing labour for the stripping, cleaning and reassembly of the cube/cylinder moulds.

No.	Item Description	Quantity
1.	Speedy moisture tester large size	6
2.	Multipurpose field scale 25 kg x 1g	2
3.	Moisture tester reagent (1 carton)	24 cans
4.	Cement Pans tapered 610 mm x 610 mm x 63 mm	12
5.	Trowel triangular blade, 180 mm long	6
6.	Trowel rectangular blade, steel, 280 mm x 115 mm	3
7.	150 mm cube form with base plate, or 150mm diameter cylinder	100
8.	Sieve, brass 8" diameter full height:	
	a. Sieve opening 2" (50 mm)	3
	b. Sieve opening 1 1/2" (37.5 mm)	3
	c. Sieve opening 1" (25 mm)	3
	d. Sieve opening 3/4" (19 mm)	3
	e. Sieve opening 1/2" (12.5 mm)	2
	f. Sieve opening 3/8" (9.5 mm)	2
	g. Sieve opening 1/4" (6.35 mm)	2
	h. Sieve mesh No. 4 (4.75 mm)	2
	i. Sieve mesh No. 8 (2.36 mm)	2
	j. Sieve mesh No. 10 (2.00 mm)	2
	k. Sieve mesh No. 16 (1.18 mm)	2
	l Sieve mesh No. 30 (0.600 mm)	2
	m. Sieve mesh No. 40 (0.425 mm)	2
	n. Sieve mesh No. 50 (0.300 mm)	2
	o. Sieve mesh No. 100 (0.150 mm)	2
	p. Sieve mesh No. 200 (0.075 mm)	6
9.	Brass pan for above	4
10.	Brass cover with ring	4
11.	Brass riddle sieve 18" diameter:	
	a. Sieve opening 2" (50 mm)	1
	b. Sieve opening 1 1/2" (37.5 mm)	1
	c. Sieve opening 1" (25 mm)	1
	d. Sieve opening 3/4" (19 mm)	1
	e. Sieve opening 1/2" (12.5 mm)	1
	f. Sieve opening 3/8" (9.5 mm)	1
	g. Sieve opening mesh No. 4 (4.75 mm)	1
12.	Quartering canvas	4
13.	Rotap sieve shaker, 220/240 V. 50 Hz.	1
14.	Large capacity Gibson sample splitter with hopper	1
15.	Sample bags, plastic lined 900 x 500 mm	2000
16.	Sample bags, paper lined 900 x 500 mm	2000
17.	Aggregate scoop pans	2
18.	Wet washing sieves 200 mesh	6
19.	Sample splitter, stainless steel, 12.5 mm chute	1
20.	Timing device 0-60 minutes	4
21.	Fine sieve brush	6
22.	Wire sieve brush	6
23.	Tamping Rod, 600 mm long, 16 mm dia.	4

24.	Yield bucket 3 dm3 (1/10 ft.3)	1
25.	Yield bucket 30 dm3 (1 ft.3)	2
26.	Slump test set	4
27.	Mortar cube moulds (12 moulds)	4
28.	Mini slump cone (as developed by the Portland Cement Association – USA)	1 set
29.	Unit weight bucket 15 dm3 (1/2 ft.3)	1
30.	Mixing bowls stainless steel 2 liter cap.	15
31.	Pans, stainless steel, rectangular	12
32.	Trays, galvanized	3
33.	Cement mould brush, brass	3
34.	Combination compression tester (150,000 kg.) Automatic	1
35.	Quality of water test kit	1
36.	Armored concrete thermometers	10
37.	Hot plate 220/240 V, 50 Hz.	4
38.	Laboratory Batch Oven, 220/240 V, 50 Hz.	2
39.	Double wall gravity convection oven 220/240V, 50 Hz.	2
40.	Dial-O-gram balance 310 x 10 mg.	1
41.	Triple beam scale	1
42.	Triple beam scale 2610 x 100 mg. (with scoop)	1
43.	Mettler precision balance (Model P-10)	1
44.	Mettler precision balance 4 kg. x 100 mg. and 10 mg.	1
45.	Platform beam scale cap 100 kg.	1
46.	Specific gravity set for fine aggregate	2
47.	Liquid limit device to ASTM D4318 with counter	2
48.	ASTM grooving tool	2
49.	Spare cups for liquid limit device	4
50.	Porcelain mixing dish	6
51.	100 ml. Graduated cylinder	6
52.	25 ml. Graduated cylinder	3
53.	500 ml. Graduated cylinder	3
54.	1000 ml. Graduated cylinder	3
55.	Flexible spatula	6
56.	Plastic limit plates	3
57.	Soil mortar	2
58.	Soil pestle	2
59.	Sand equivalent test set (*without shaker)	2
60.	Sand equivalent stock solution	30 (bots)
61.	Aspirator jar 5 litre capacity	4
62.	Modified compaction mould 150 mm (6") dia.	2
63.	Standard compaction mould 100 mm (4") dia.	2
64.	Modified compaction hammer	2

65.	Sample ejector	1
66.	Straight edge	6
67.	Density pick	6
68.	Chisel	4
69.	Rubber mallet	4
70.	Sampling spoons	6
71.	Sand density cone	3
72.	Top Hat Calibration complete	1
73.	Field density plate	6
74.	Replacement jugs, 4.5 L (1 gallon) size	12
75.	Density sand	2000 kg
76.	Moisture tins, 85 ml. (3 oz.) capacity	50
77.	Moisture tins, 170 ml. (6 oz.) capacity	50
78.	Heat insulating gloves	6 pairs
79.	Laboratory tongs	3
80.	Stopwatch	2
81.	Sample cans, 10 dm3 capacity	100
82.	Sample cans, 1 dm3 capacity	100
83.	Spatula 150 mm long blade x 25 mm wide	2
84.	Large scoop	2
85.	Large pick	2
86.	Shovel square edge	4
87.	Soil auger 150mm	1
88.	Extra head	1
89.	25 mm Square tamping bar for150 mm cubes	4
90.	Galvanised steel tank for curing concrete specimens approx with stand 3 metre	2
91.	Mechanical loading press, 4000 kg	1
92.	CBR Moulds, (inside diameter: 152.4 mm, height: 177.8 mm) with perforated base.	15
93.	Spacer Disc, 150 mm (5-15/16") diameter 61.4 mm (2.416") high,	2
94.	Dial indicator	4
95.	Swell plate	15
96.	Tripod attachment	3
97.	Surcharge weight, 2.3 kg (5 lbs.) annular disc	24
98.	Surcharge weight, 2.3 kg (5 lbs.) slotted	24
99.	Filter papers for CBR test moulds	20 boxes
100.	Volume 1 and 2 of AASHTO Specification	1 set
101.	Flakiness plate (B.S 812)	2
102.	Elongation gauge (BS 812)	1
103.	Marshall compaction moulds	12
104.	Dial thermometers	6
105.	Reflux extractor, glass, 4000 g capacity	2
106.	Filter papers for above	80 packs
107.	Spare glass jars for above	10
108.	Centrifuge extractor, 3000 g cap	2
109.	Bowl for above, 3000 g cap	2

110.	Tube sampler	2
111.	Nickel evaporating dish	5
112.	Bunsen burner	2
113.	Glass bituminometer, 750 ml.	5
114.	Glass bituminometer, 1500 ml.	5
115.	Thermostatic water bath at least 150 mm deep with temperature control (60oC ± 1/2oC) and fitted with shelf for supporting Marshall stability specimen 50 mm from bottom of tank	1
116.	Mechanical mixer with capacity of 2 kg and a mixing bowl surrounded by a heating element with a suitable control	1
117.	Thermostatic refrigerated water bath at least 150 mm deep with temperature control (25oC ± 1/2oC) for use with bituminometer	1
118.	Marshall Asphalt Stability Test Set complete (220/240 V, 50 Hz)	1
119.	Bitumen sampler (Bacon device)	2
120.	Sample splitter, Riffler, Stainless steel	1
121.	Wide mouth, clear glass bottles, 60 ml (2 oz.) capacity, screw-on-top	12 bots
122.	Aluminium beakers, 500 ml.	12
123.	Thermometre 18-28oC range	3
124.	Pocket type thermometers 0-25oC	3
125.	Weights, stainless steel :	
	a) 20 kg.	30
	b) 10 kg.	4
	c) 5 kg.	4
	d) 1 kg.	4
126.	Tape measure (3 metres)	3
127.	Tape measure (5 metres)	3
128.	Funnels, 300 mm diameter	3
129.	Funnels, 150 mm diameter	3
130.	Funnels, 75 mm diameter	3
131.	Tripod stand	3
132.	Platform scale - 250 kg x 100 g. (e.g. Avery Model 32054 BA)	1
133.	Insulated box - 300 mm x 300 mm x 300 mm	3
134.	Trichloroethylene	400 litres
135.	Measuring cups, Pyrex glass, graduated in 10 ml divisions	2
136.	5 ml. or 10 ml. Glass hypodermic syringe (as used for injections) graduated in 0.1 ml. divisions	2
137.	Beakers, Pyrex glass, 500 ml. cap	6
138.	Dropping bottles TK pattern, 100 ml.	4
139.	4 m Hi Lo Detector with attachments	1
140.	4 m straight edge and wedge device for measuring surface irregularity	2
141.	Wheelbarrow	3
142.	350 mm dia x 450 mm deep plastic dustbin	6

143.	Electronic Calculator, scientific multifunction with memory and statistical functions	4
144.	Min/Max thermometer	2
145.	Wire gauze asbestos disc for use on hot plates	6
146.	Surface coating thickness gauge (paint) Elecometer	1
147.	Rubber tubing 12.7 mm bore	6 m
148.	Rubber tubing 6 mm bore x 12.7 mm OD	6 m
149.	Sieve shaker for 18" (457 mm) sieves 220/240 V 50 Hz. with circular and vertical movement non-tapping	1
150.	Sand Equivalent Shaker 220/240 V 50 Hz with timer	1
151.	Automatic Compactor for Proctor and Mod. AASHTO compaction tests	1
152.	Tank for soaking CBR samples and for determining weight of immersed materials min. size 1000 mm x 600 mm x 600 mm	1
153.	Automatic compactor for asphalt compaction with facility to automatically rotate sample during compaction 220/240 V 50 Hz	1
154.	DIN percussion type Dutch Cone Penetration Apparatus – hand operated	1
155.	Frequency gauge for checking concrete Vibrators	1
156.	Standard Penetrometer complete with penetration needles	1
157.	Softening Point Apparatus c complete plus attachments	1
158.	Purpose built fume cupboard with extraction system for use in asphalt analysis	1
159.	Exterior covered storage area for solvents for asphalt analysis including feed and tap system to the interior of laboratory	1
160.	Colour comparator	1
161.	Laboratory portable concrete mixer-drum type 110 litre 75/hp/220 V/50 cy/1 ph	1
162.	Equipment for ASTM C232 Bleeding of Concrete	1
163.	Equipment for BS 1377 Ion Exchange (sulphates, chlorides)	1
164.	Equipment for ASTM C88 Soundness of aggregates by Sodium or Magnesium sulphate	1
165.	ASTM D1558 Proctor Penetrometer	1
166.	Pyrex Glass Breakers 10 ml, 50 ml, 250 ml, 1000 ml	6 each
167.	Equipment for ASTM C403 Setting, time by penetration resistance	1
168.	Equipment for ASTM C360 Ball penetration of fresh concrete	1
169.	Tool kit comprising – screwdrivers 2No. large, 2 No. small electrical screwdrivers, (circuit testing), 2 pairs of pliers, 2 No. 450 mm stilson wrenches, adjustable spanners – self grip	

	wrench; hacksaw and blades; smooth	
	and bastard files; electric soldering iron flux	
	and solder; 2 No. clawhammer; panel saw,	
	range of open ended and ring spanners	
	(metric and ANF inch sizes)	1 set
	Miscellaneous apparatus for testing	
	Cement coating of aggregate for Cement	
	content AASHTO T211	
	Other miscellaneous equipment in the quantities required to perform all specified tests.	
	Supplies of the following:	
	Distilled Water	
	Phenophthalein Indicator	
	Ethyl Alcohol Absolute	
	Unleaded Kerosene	
	Hydrochloric Acid	
	Barium chloride	
	Sodium sald of rhodizonic acid or	
	Sodium rhodizonate	
	Potassium sulphate	
	Ammonium or Potassium thiocynate	
	Nitric acid	
	Silver nitrate	
	Volhord indicator	
	Plus other reagents required for testing	
170.	Coring Drill	1
171.	Core Cutting Machine	1
172.	Wind velocity gauge	1
173.	Los Angeles Abrasion Testing Equipment	1
174.	Soundness Testing Equipment	1
175.	Rolling Thin Film Oven	1
176.	Pressure Aging Vessel	1
177.	Dynamic Shear Rheometer	1
178.	Rotational Viscometer	1
179.	Bending beam Rheometer	1
180.	Direct Tension Tester	1
181.	Oedometer	1
182.	Permeability Testing Machine	
	(Falling Head and Constant Head)	1
183.	Compressive strength and young	
	modulus testing machine	1
184.	Nuclear density measurement apparatus	1

NB: All consumable items are to be replenished as needs dictate.

1004. ASPHALT BATCHING PLANT(S) LABORATORY

1004.01 General Requirements

In addition to providing a fully equipped site laboratory in accordance with this Section (Site Laboratories) of these Specifications, the Contractor shall provide suitable facilities at the asphalt batching plant(s) to enable the Engineer to carry out all necessary tests on the raw materials and mixes. Such facilities will be subject to the Engineer's approval and the preparation of asphalt mixes shall not be allowed until the facilities have been approved by the Engineer.

The Contractor shall bear all the costs pertaining to obtaining specimens of materials, asphalt mixes and samples cut from the paving courses after compaction, including the provision of necessary equipment and plant for obtaining these specimens and samples.

This work shall be performed in the presence of the Engineer. The Engineer will take possession of the samples upon their removal from the roadway.

In particular, the Contractor shall provide a portable coring machine and bits for taking full depth cores of all bituminous paving courses. The diameter of the bit will be 100mm when the maximum nominal size of aggregate in the pavement is 25mm or less, and 150mm when the maximum nominal size of aggregate is greater than 25mm, as per AASHTO T230.

The coring machine shall be available to the Engineer upon request. Should the coring machine not be available when required, the Engineer may make other arrangements for taking the required cores and all costs incurred will be deducted from the payments due to the Contractor.

No payment will be made for this item which is dealt with as incidental.

SECTION 11: PRESTRESSED CONCRETE WORKS

1100 - GENERAL

1100.01 SCOPE

This Section contains the Specifications for in situ and precast pre-tensioned and post-tensioned concrete works which consist of supplying and fixing formwork, falsework and temporary works; supplying and placing of prestressing steel, metal or plastic (polyethylene or polypropylene) ducting and anchorages; supplying concrete of the class specified, transporting and placing in prepared forms, tamping, vibrating, finishing and curing, including pointing and jointing with cement mortar; tensioning of prestressing steel and pressure grouting of ducts; supplying and installing all joint materials, other than fixed and neoprene expansion joints; all in accordance with this Section, Section 5 (Concrete Works) and other Sections of these Specifications and in conformity with the Drawings and other Contract Documents and with AASHTO LRFD Bridge Construction Specifications.

1100.02 SCHEDULING OF POST-TENSIONED CONCRETE WORK

The scheduling of all post-tensioned concrete work shall be such that construction of each individual superstructure unit can be completed within a 90 day period commencing with the first concrete pour through completion of the post-tensioning and duct grouting operations.

The Contractor shall have sufficient materials on hand prior of commencing work on any given superstructure unit to ensure completion of the unit within the specified 90 day period.

1100.03 QUALITY ASSURANCE

1100.03.1 Standards and Codes

Standards and codes shall be as set forth in Section 5 (Concrete Works) of these Specifications. The following standard and codes in their latest edition shall be applied particularly to works covered by this Section.

AASHTO

AASHTO LRFD Bridge Design Specifications
AASHTO LRFD Bridge Construction Specifications

M 157	Ready-Mixed Concrete
M 203	Standard Specification for Steel Strand, Uncoated Seven-Wire for Concrete Reinforcement
M 204	Standard Specification for Uncoated Stress-Relieved Steel wire for Prestressed Concrete
M 275	Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete
T 277	Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

ASTM

A 416	Steel Strand, Uncoated Seven-Wire for Concrete Reinforcement.
A 421	Uncoated Stress-Relieved Wire for Pre-stressed Concrete
A 722	Uncoated High-Strength Steel Bars for Prestressing Concrete
C 33	Standard Specification for Concrete Aggregates
C 150	Portland Cement
C 186	Standard Test Method for Heat of Hydration of Hydraulic Cement
C 403	Time of Setting of Concrete Mixtures by Penetration Resistance
C490	Standard Practice for Use of Apparatus for the Determinates of the Length Change of Hardened Cement Paste,Mortar, and Concrete
C 939	Test Method for Flow of Grout for Preplaced-Aggregate Concrete in the Laboratory
C 940	Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
C1202	Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

BS

BS EN 206-1	Concrete Part 1: Specification, Production, and Conformity.
BS EN 197	Cement Specification BS 4447 Performance of Prestressing Anchorages for Post-Tensioned Construction
BS 4486	Specification for Hot Rolled and Hot Rolled and Processed High Tensile Alloy Steel Bars for the Prestressing of Concrete
BS EN 5896	High Tensile Steel Wire and Strand for the Prestressing of Concrete
BS EN 12350	Testing Fresh Concrete
BS EN 12390	Testing Hardened Concrete,
CP 116	The Structural Use of Precast Concrete

Federal Specification

MMM-G-650A	Epoxy Bonding Agent
SS-A-701	Bituminous Protective Coatings
MIL-P-3420H	Wrapping Materials, Volatile Corrosion Inhibitor Treated Opaque

US Corps of Engineers

CRD-C79	Test Method for Compressive Strength of Mortar for Use in Evaluating Water for Mixing Concrete

1100.03.2 Pre-Tensioning and Post-Tensioning Systems Constructor's Qualifications

a. Before a pre-tensioning or post-tensioning sub-contract is awarded, the Contractor shall submit to the Engineer for approval, the name and address of the organization proposed for the performance of the tensioning operations under these Specifications.

b. The named proposed organization shall submit evidence that it has, for the preceding five years, performed work comparable to the tensioning work under these Specifications, and shall verify this experience by citing references for substantial quantities of work comparable to those contained in the Contract which have been successfully accomplished. In addition, the sub-contractor shall submit the following for quality assurance:

- Manufacturer qualifications,
- Erector qualifications,
- Welder qualifications,
- Testing qualifications.

1100.04 SAMPLING AND TESTING

1100.04.1 Concrete

Concrete sampling, testing and frequency of testing shall be in accordance with Section 5 (Concrete Works) of these Specifications and as specified herein.

1100.04.2 Prestressing Steel

Prior to the Contractor ordering prestressing steel he shall obtain the Engineer's approval of the proposed manufacturer by submitting representative samples, certification of compliance and test results from a recognized independent laboratory which show conformance with these Specifications. All reels of prestressing steel delivered to Site shall be accompanied by an inspection certificate furnished by the manufacturer indicating compliance with these Specifications and the number of reels represented by the Certificate and shipped for this project.

The Engineer may select random samples for testing from the materials delivered to Site. The actual strength of the prestressing steel shall not be less than specified by the applicable Standard.

i. Pretensioning Tendons: one sample at least 1500 mm long shall be furnished in accordance with the requirements of Sub-Section 9.1 of ASTM A 416/A 416M.

ii. Post-Tensioning Tendons: for 20 tonnes, or portion thereof, lot of material used in the work:

- For wires not requiring heading: sufficient length to make up one parallel-lay cable 1500 mm long consisting of the same number of wires as the cable to be furnished.
- For strand to be furnished with fittings: 1500 mm between near ends of fittings.
- For bars to be furnished with threaded ends and nuts: 1500 mm between threads at ends.

The Contractor shall have no claim for additional compensation if his work is delayed while awaiting approval of the materials furnished for testing.

1100.05 SUBMITTALS

1100.05.1 Shop Drawings

a. Shop drawings shall be submitted to the Engineer for approval in accordance with Section 5 (Concrete Works) of these Specifications, and as specified herein.

b. Supplementing the requirements for shop drawings specified in Section 5(Concrete Works) of these Specifications, the Contractor shall include with the shop drawings a description of the equipment to be used and his proposed procedure for construction.

1. For post-tensioned concrete work, the details of the ducts and the method of holding the ducts in position, tendon sizes, jack clearances and procedures, stressing sequences, grout connections and vents, anchorage details and bonding and grouting procedures.

2. For pre-tensioned concrete work, the details for fabrication, pre-tensioning, debonding, detensioning and curing.

1100.05.2 Certificates

Certified copies or original certificates from manufacturers shall be furnished stating that the materials and equipment to be provided conform to these Specification requirements.

1100.05.3 Test Reports

The Contractor shall furnish to the Engineer, reports of material tests and records as specified herein, or as further requested by the Engineer.

1100.06 MATERIAL DELIVERY, STORAGE AND HANDLING OF PRESTRESSING STEEL

a. Prestressing steel shall be protected continuously against physical damage and rust or other results of corrosion from the time of manufacture to the time of grouting or encasing in concrete.

Physically damaged prestressing steel will be rejected by the Engineer. The development of visible rust or other results of corrosion will be sufficient cause for rejection if so directed by the Engineer.

b. Prestressing steel shall be suitably packaged in containers or shipping crates to protect the steel against physical damage and corrosion during shipping and storage.

Any corrosion inhibitor that may be used shall have no deleterious effect on steel or concrete or bond strength of concrete to steel. The Contractor may use the following methods of corrosion protection:

i. An inhibitor placed within the transport package.
ii. An inhibitor type packaging material.
iii. An inhibitor applied directly to the steel, subject to the prior approval of the Engineer.

c. Shipping packages shall be clearly marked with a statement that the packages contain high-strength prestressing steel, and that care is to be used in handling. The markings shall also show the type, kind and amount of corrosion inhibitor used, including the date when placed and safety orders and instructions for use.

1101 - MATERIALS

1101.01 PRESTRESSING SYSTEMS

1101.01.1 General Requirements

Pre-tensioning and post-tensioning systems for concrete structures shall be of internationally recognised types acceptable to the Engineer as indicated on the Drawings, and meeting the following requirements:

a. Strand shall be uncoated, seven wire, high-tensile, cold drawn, stress-relieved steel conforming to ASTM A416/A416M (AASHTO M 203), Grade 270, or BS EN 5896 and shall have a low relaxation (as described in the supplement to A416) where shown on the Drawings.

b. Wire shall be uncoated, stress-relieved, cold drawn, round, high tensile steel, conforming to ASTM A421/A421 M (AASHTO M 204), or BS EN 5896, and having a minimum tensile strength of 16,900 kg/cm2 wire shall not be oil tempered.

c. High Tensile Steel Bar: High tensile steel bars for prestressed concrete shall comply with ASTM A 722/A 722 M (AASHTO M 275) or with BS 4486.

d. Anchorage assemblies, jacks, gauges, grout fittings, and other related equipment and accessories shall be standard with the systems manufacturers and shall be approved by the Engineer.

e. Unless otherwise shown on the Drawings, ducting for prestressing strand shall be flexible, bright, interlocked, mortar and grout tight and fabricated of not lighter than 28 gauge steel. Ducts shall be at least 6mm larger than the nominal diameter of the strand or wire bundles and the cross sectional area shall be at least 2.5 times that of the net steel area. Ducts shall have grouting connections at each end and shall have vents/drains at all intermediate high and low points.

f. Epoxy bonding agents shall conform to FS MMM-G-650A.

g. Bituminous protective coating shall conform to FS SS-A-701.

1101.01.2 Alternative Tensioning Systems

Alternative systems or tensioning systems of other manufacturers, which are comparable and equal in all respects to the specified systems may be used, provided the proposed alternative tensioning systems have the prior approval of the Engineer.

1101.02 CONCRETE

Concrete for pre-tensioning and post-tensioning shall be Class K450 as specified in Section 5 (Concrete Works) of these Specifications unless otherwise noted on the Drawings or in other of the Contract Documents.

1101.03 DUCT GROUT MATERIALS

1101.03.1 General Requirements

Grout shall be in accordance with the requirements of AASHTO LRFD Bridge Construction Specifications Article 10.9.

Unless otherwise directed or agreed as a result of grouting trials, uniquely designed grouts shall consist only of ordinary Portland cement and water. The water-cement ratio shall be as low as possible consistent with necessary workability and under no circumstances be higher than 0.45 and not be subject to bleeding in excess of 2 percent after 3 hours, or 4 percent maximum. When measured at 18 degrees C in a covered glass cylinder approximately 100 mm water shall be reabsorbed after 24 hours.

Grout shall be mixed for a minimum of two minutes and until a uniform consistency is obtained. The pumpability of the grout may be determined in accordance with the US Corps of Engineers Method CRD-C79 in which case the efflux time of the grout sample immediately after mixing shall not be less than 11 seconds.

Admixture containing chlorides or nitrates shall not be used. Other admixtures may be used only with the written permission of the Engineer and shall be applied strictly in accordance with the manufacturer's

instruction.

The design for grout mix shall be tested in accordance with ASTM C 490 for longitudinal change. Each design mix and each batch mix shall be tested for vertical dimensional change.

Daily field testing of the grout for the following properties shall be required:

i. Fluidity to ASTM C 939 or the modified test described in AASHTO LRFD Bridge construction Specification Table 10.9.3-2,

ii. Bleed at 3 h to ASTM C 940 as modified in AASHTO LRFD Bridge construction Specification Table 10.9.3-2,

iii. Permeability to ASTM C1202 (AASHTO T 277).

1101.03.2 Portland Cement

Ordinary Portland cement (OPC) conforming to ASTM C 150 Type I or BS EN 197. The heat of hydration shall not exceed 325 kj/kg when tested in accordance with ASTM C 186. C_3A content shall be a minimum of 8 percent and a maximum of 13 percent.

1101.03.3 Water

Water shall conform to the requirements of Section 5 (Concrete Works) for these Specifications.

1101.03.4 Reinforcing Steel

Reinforcing steel shall conform to the requirements of Section 5 (Concrete Works) of these Specifications.

1102 - POST-TENSIONED CONCRETE CONSTRUCTION

1102.01 GENERAL

The Contractor shall submit to the Engineer for review complete details of the method, materials and equipment he proposes to use in the tensioning operations, including any additions or rearrangement of reinforcing steel from that shown on the Drawings. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, working stresses, anchoring stresses, type of ducts, and all other data pertaining to the tensioning operation, including the proposed arrangement of the prestressing steel in the members, pressure grouting materials and equipment. The Contractor shall not cast any member to be tensioned before review of the shop detail drawings is complete and approved by the Engineer.

1102.02 FORMWORK

1102.02.1 General Requirements

Formwork, shoring and removal of forms shall be as specified in Section 5 (Concrete Works) of these Specifications and as further specified herein.

1102.02.2 Installation

Falsework and forms shall be set to provide the structural camber indicated on the Drawings for long time deflection, and shall conform to the required lines and grades.

1102.03 PLACING POST-TENSIONING SYSTEMS

1102.03.1 Placement of Ducts

Ducts shall be rigidly supported at the proper locations in the forms by ties to reinforcing steel which are adequate to prevent displacement during concrete placement. Supplementary support bars shall be used where needed to maintain proper alignment of the duct. Hold-down ties to the forms shall be used when the buoyancy of the ducts in the fluid concrete would Iift the reinforcing steel.

Polyethylene duct and metal duct for longitudinal or transverse post-tensioning in the flanges shall be supported at intervals not to exceed 600 mm. Polyethylene duct in webs for longitudinal post-tensioning shall be tied to stirrups at intervals not to exceed 600 mm, and metal duct for longitudinal post-tensioning in webs shall be tied to stirrups at intervals not to exceed 1200 mm.

Joints between sections of duct shall be coupled with positive connections which do not result in angle changes at the joints and will prevent the intrusion of cement paste. Joints in adjacent ducts shall be staggered by at least 300 mm.

After placing of ducts and reinforcement and forming is complete, an inspection shall be made to locate possible duct damage. All unintentional holes or openings in the duct shall be repaired prior to concrete placing.

Grout openings and vents shall be securely anchored to the duct and to either the forms or to reinforcing steel to prevent displacement during concrete-placing operations.

After installation in the forms, the ends of ducts shall at all times be sealed as necessary to prevent the entry of water or debris.

Where members are made up of precast units stressed together, the ducts in the joints between the units shall be in perfect alignment and joined securely so as to allow unimpeded cable threading and pulling and prevent the ingress of the epoxy mortar used for gluing the several units together before stressing. Details of such joints shall first be approved by the Engineer. The tolerance in the location of the sheath shall be plus or minus 3 mm.

Additionally the following shall apply:

i. Entrance and exit angles of tendon paths at anchorages and/or at faces of concrete shall be within ± 3 degrees of desired angle measured in any direction and any deviations in the alignment are accomplished with smooth transitions without any kinks.

ii. Angle changes at duct joints shall not be greater than ±3 degrees in any direction and must be accomplished with smooth transitions without any kinks.

iii. Locate anchorages within ± 3 mm of desired position laterally and ±25 mm along the tendon except that minimum cover requirements shall be maintained.

iv. Position anchorage confinement reinforcement in the form of spirals, multiple U-shaped bars or links to be properly centered around the duct and to start within 12 mm of the back of the main anchor plate.

v. If conflicts exist between the reinforcement and post-tensioning duct, position the post-tensioning duct and adjust the reinforcement locally with the Engineer's approval.

Ducts shall be kept free of any matter detrimental to the bond between the sheath and the grout and, except for material sealing a sheath joint, between the sheath and the concrete.

All ducts for continuous structures shall be supplied with outlets at the high and low points of the duct profile, except where the profile changes are small, as in continuous slabs, and at additional locations as specified in the Contract Documents. Low-point outlets shall remain open until grouting is started.

Upon completion of concrete placement, the Contractor shall prove that the post-tensioning ducts are free and clear of any obstructions or damage and are able to accept the intended post-tensioning tendons by passing a torpedo through the ducts. The torpedo shall have the same cross-sectional shape as the duct, and 6 mm smaller all around than the clear nominal inside dimensions of the duct. No deductions shall be made to the torpedo section dimensions for tolerances allowed in the manufacture or fixing of the ducts. For straight ducts, a torpedo at least 600 mm long shall be used. For curved ducts, the length shall be determined so that when both ends touch the outermost wall of the duct, the torpedo is 6 mm clear of the innermost wall. If the torpedo will not travel completely through the duct, the Engineer shall reject the member, unless a workable repair can be made to clear the duct, to the satisfaction of the Engineer. Upon completion of the repairs, the torpedo shall pass through the duct easily, by hand, without resorting to excessive effort or mechanical assistance.

Before stressing and grouting internal or external tendons, install all grout caps, inlets and outlets and test the tendon with compressed air to determine if duct connections require repair. In the presence of the Engineer, pressurize the tendon to 345 kPa and lock-off the outside air source. Record pressure loss for 1 minute. A

pressure loss of 170 kPa is acceptable for tendons having a length of equal to or less than 45 m and a pressure loss of 100 kPa is acceptable for tendons longer than 45 m. If the pressure loss exceeds the allowable, repair leaking connections using methods approved by the Engineer and retest.

The ends of all ducts shall be sealed and protected until the tendon is threaded through and the stressing operations are commenced. Where tendons in sheaths or sheath on its own are left exposed to atmosphere, rust inhibitors shall be used as per the maker's specification to prevent rusting and corrosion of the inside of sheaths. They shall be flushed with clean water before the tendons are grouted. The Contractor is responsible for carrying out these measures at his own expense.

1102.03.2 Placement of Prestressing Steel

General:

i. All wires or strands stressed at the same time shall be taken from the same parcel. Each cable shall be tagged with its number and the coil number of the steel used.

ii. Tendons shall not be welded within the length to be tensioned and, unless other methods of cutting are approved by the Engineer, tendons shall be sawn or cropped using an abrasive disc cutter.

iii. Tendons shall be built into the work strictly in accordance with the system which is being employed.

iv. Tendons shall not be kinked or twisted and individual wires or strands shall be readily identifiable at each of the members. No strand which has become unravelled shall be used in the work.

Placement for Pretensioning:

i. Prestressing steel shall be accurately installed in the forms and held in place by the stressing jack or temporary anchors and, when tendons are to be draped, by hold-down devices. The hold-down devices used at all points of change in slope of tendon trajectory shall be of an approved low-friction type.

ii. Prestressing steel shall not be removed from its protective packaging until immediately prior to installation in the forms and placement of concrete. Openings in the packaging shall be resealed as necessary to protect the unused steel. While exposed, the steel shall be protected as needed to prevent corrosion.

Placement for Post-Tensioning:

i. All prestressing steel preassembled in ducts and installed prior to the placement of concrete shall be accurately placed and held in position during concrete placement.

ii. When the prestressing steel is installed after the concrete has been placed, the Contractor shall demonstrate to the satisfaction of the Engineer that the ducts are free of water and debris immediately prior to installation of the steel. The total number of strands in an individual tendon may be pulled into the duct as a unit, or the individual strand may be pulled or pushed through the duct.

iii. Anchorage devices or block-out templates for anchorages shall be set and held so that their axis coincides with the axis of the tendon and anchor plates are normal in all directions to the tendon.

iv. The prestressing steel shall be distributed so that the force in each girder stem is equal or as required by the Contract Documents, except as provided herein.

v. For box girders with more than two girder stems, at the Contractor's option, the prestressing force may vary up to five percent from the theoretical required force per girder stem provided the required total force in the superstructure is obtained and the force is distributed symmetrically about the centerline of the typical section.

Protection of Steel After Installation:

i. Prestressing steel used in post tensioned concrete members that is not grouted within the time limit specified below, shall be continuously protected against rust or other corrosion by means of a corrosion inhibitor placed in the ducts or directly applied to the steel. The prestressing steel shall be so protected until grouted or encased in concrete. Prestressing steel installed and tensioned in members after placing and curing of the concrete and grouted within the time limit specified below will not require the use of a corrosion inhibitor

described herein and rust which may form during the interval between tendon installation and grouting will not be cause for rejection of the steel.

ii. After tendons are placed in ducts, the openings at the ends of the ducts shall be sealed to prevent entry of moisture.

iii. When steam curing is used, unless anchorage systems mandate its installation, steel for post-tensioning shall not be installed until the steam curing is completed.

iv. Such tendons shall be protected against corrosion by means of a corrosion inhibitor placed in the ducts or on the steel, or shall be stressed and grouted within seven days after steam curing.

v. Whenever electric welding is performed on or near members containing prestressing steel, the welding ground shall be attached directly to the steel being welded. All prestressing steel and hardware shall be protected from weld spatter or other damage.

1102.03.3 Placement of Anchorages

The Contractor is responsible for the proper placement of all materials according to the Design Documents of the Engineer and the requirements stipulated by the anchorage device supplier. The Contractor shall exercise all due care and attention in the placement of anchorage hardware, reinforcement, concrete and consolidation of concrete in anchorage zones.

Modifications to the local zone details verified under provisions of AASHTO LRFD Bridge Design Specifications Article 5.10.9.7.3 and AASHTO LRFD Bridge Construction Specifications Article 10.3.2.3, “Special Anchorage Device Acceptance Test”, shall be approved by both the Engineer and the anchorage device supplier.

1102.03.4 Identification and Testing

All wire, strand, or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be likewise identified.

Before approval, at least two samples of the prestressing steel shall be tested at the Contractor's expense, at an approved independent laboratory for chemical composition, mechanical strength, relaxation and physical characteristics.

Subsequently, each lot of wire or bars and each reel of strand reinforcement shall be accompanied by a manufacturer's certificate of compliance, a mill certificate, and a test report. The mill certificate and test report shall include:

i. Chemical composition (not required for strand),
ii. Cross-sectional area,
iii. Yield and ultimate strengths,
iv. Elongation at rupture,
v. Modulus of elasticity, and
vi. Stress strain curve for the actual prestressing steel intended for use.

All values certified shall be based on test values and nominal sectional areas of the material being certified.

1102.03.5 Protection of Prestressing Steel

All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting. Prestressing steel shall also be free of deleterious material such as grease, oil, wax or paint. Prestressing steel that has sustained physical damage at any time shall be rejected. The development of pitting or other results of corrosion, other than rust stain, shall be cause for rejection.

Prestressing steel shall be packaged in containers or shipping forms for the protection of the strand against physical damage and corrosion during shipping and storage. A corrosion inhibitor which prevents rust or other results of corrosion shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier-type packaging material, or when permitted by the Engineer, may be applied directly to the steel. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

The shipping package or form shall be clearly marked with a statement that the package contains high-strength prestressing steel, and the type of corrosion inhibitor used, including the date packaged.

All anchorages, end fittings, couplers, and exposed tendons, which will not be encased in concrete or grout in the completed work, shall be permanently protected against corrosion.

Corrosion Inhibitor:

i. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete or grout.

ii. Corrosion inhibitor shall consist of a vapor phase inhibitor (VPI) powder conforming to the provisions of Federal Specification MIL-P-3420H or as otherwise approved by the Engineer.

iii. When approved, water soluble oil may be used on tendons as a corrosion inhibitor.

1102.04 CONCRETE WORK

1102.04.1 General Requirements

Concrete work for post-tensioned concrete works shall comply with the applicable provisions of Section 5 (Concrete Works) of these Specifications for materials, testing, proportioning, mixing, placing, finishing and curing and as further specified herein.

1102.04.2 Checking

Prior to placing concrete, tendon profiles shall be rechecked to ensure that proper location and concrete cover will be obtained. Any ducting found to be damaged shall be repaired or replaced as directed by the Engineer.

1102.04.3 Prestressing Steel and Ducting

Prior to placing forms for box girder deck slabs, the Contractor shall demonstrate, to the satisfaction of the Engineer that either the prestressing steel is free and unbonded in the duct or, if prestressing steel has not yet been placed, that all ducts are unobstructed.

1102.04.4 Placing of Concrete

The Contractor shall exercise care during concrete placement to prevent concrete from entering all ducts and anchorages. Concrete shall be placed in such a manner that tendon alignment and reinforcement positions are maintained and concrete shall be vibrated with particular attention at tendon anchorage locations to ensure optimum compaction and penetration at these points.

1102.04.5 Curing of Concrete

Curing of Concrete shall be in accordance with Section 5 (Concrete Works) of these Specifications.

1102.04.6 Records

The Contractor shall keep records showing the date and time of placement of cast-in-place, post-tensioned in each portion of the structure. These records shall be available for examination, at all times, by the Engineer. Upon completion of construction of each structure, two copies of such records shall be submitted to the Engineer.

1102.05 STRESSING OPERATIONS

1102.05.1 General Requirements

a. Tensioning shall be carried out only in the presence of the Engineer or his representative, unless permission in writing has been obtained to the contrary.

b. The Contractor shall provide, at no additional cost to the Employer, a Technician who is skilled in the post-tensioning method to give such aid and instruction in the use of the tensioning equipment and installation of the prestressing steel as, in the opinion of the Engineer, may be necessary to obtain the specified results. The Contractor shall submit for approval the name and details of experience of the technician proposed for

this post.

c. Prior to post-tensioning any member, the Contractor shall demonstrate to the satisfaction of the Engineer that the prestressing steel is free and unbonded in the duct, and that members are free to accommodate the horizontal and vertical movement resulting from the application of prestress.

1102.05.2 Transfer Strength

Tendons shall not be tensioned until all the concrete to be stressed has attained a compressive cube strength as specified in the Drawings but not less than 300 kg/cm^2, based on the minimum of two cube tests per pour.

The test cubes shall be made and tested in accordance with BSEN 12350 and BSEN 12390, but shall be cured in similar conditions to the concrete to which they relate. The Contractor shall cast sufficient cubes to demonstrate that the required strength of the Concrete at transfer has been reached.

Where members consist of jointed segments, the strength of the jointing material at transfer shall be at least equal to the specified transfer strength of the members.

1102.05.3 Post-Tensioning System

All post-tensioning shall be by means of hydraulic jacks and pumps calibrated with a suitable load cell or pressure gauge capable of determining the load in the tendon with an accuracy of $\pm$1% of full scale reading. Hydraulic jacks and pumps shall be recalibrated if the calibrations certificates are more than 6 months old or as required by the Engineer. The Contractor shall make arrangements for all load cells and pressure gauges to be calibrated on suitable equipment before work starts, and during the progress of the works as directed by the Engineer. If inconsistencies occur between the measured elongation and the load reading, the cause shall be determined by the Contractor and he shall propose remedial action for the Engineer's approval. Should inconsistencies continue to occur after the approved remedial action has been taken the load cell or pressure gauge shall be recalibrated.

Measurement of load and the corresponding extension shall be recorded at a minimum of six intervals during stressing, unless otherwise agreed, the intervals being determined by the Engineer.

1102.05.4 Design Data for Post-Tensioning System

The jacking location of the tendons is shown on the Drawings.

The Drawings indicate the friction coefficients, wedge pull-in and other losses of prestress used in the design and the specified jacking forces to be applied to each tendon. The Contractor shall design the post-tensioning system to give final prestress forces at any section not less than those which would result from the data given on the Drawings. Values of friction coefficients, pull-in and other losses to be used in the design shall be agreed with the Engineer. Appropriate allowance shall also be made for anchorage friction and jack losses.

1102.05.5 Testing of Friction Losses

The total forces and calculated extensions shall be agreed with the Engineer before stressing is commenced.

One tendon shall be checked for friction loss at the onset of post-tensioning by jacking from one end only and measuring the force at each end of the tendon.

If the friction loss recorded in the test exceeds the friction loss computed from the design values of friction coefficients, the Contractor shall with the approval of the Engineer, repeat the test taking whatever steps are necessary to obtain the design load in the tendon. These steps shall be applied to the stressing of all subsequent tendons. The test shall be repeated after stressing every one thousand tendons.

1102.05.6 Tensioning

Tendons shall be tensioned at a gradual and steady rate.

Each tendon shall be tensioned to the agreed total force so that the extension of the tendons is within $\pm$5% of the agreed calculated extension. The tensioning stress shall be as shown on the Drawings but in no case shall the prestressing steel be tensioned above 80% of the ultimate tensile strength nor 90% of the yield stress of the wire or strands as per AASHTO LRFD Bridge Design Specifications.

Tendons in continuous span post-tensioned structures shall be tensioned by jacking at both ends except where indicated otherwise on the Drawings. Tendons in simple span and stage-constructed post-tensioned structures may be tensioned by jacking from one end only and as directed by the Engineer.

When tensioning from both ends of a tendon, the Contractor shall provide an adequate method of communication between stressing teams, so that all stressing operations may be effectively synchronized.

When tensioning from one end only, the pull-in at the end remote from the jack shall be accurately measured and the appropriate allowance made in the measured extension at the jacking end.

If the pull-in of the tendons on completion of anchoring is greater than that agreed by the Engineer, the load shall be released at a gradual and steady rate and tensioning carried out afresh.

1102.05.7 Tensioning Records

The Contractor shall keep records of the elongation of and tension applied to each tendon and these records shall be submitted to the Engineer promptly upon the completion of tensioning of each member. At the time of tensioning the first member, the prestresses in the individual tendons shall be checked to establish a procedure of ensuring uniform results. At any later time a recheck may be ordered by the Engineer if it appears that the design stresses are not being obtained.

1102.05.8 Cropping of Tendons

The Contractor shall obtain written permission from the Engineer before cropping any tendons.

Trimming shall be carried out with a disc cutter; under no circumstances shall flame cutting be permitted.

1102.06 GROUTING OF TENDONS

1102.06.1 General

After the tensioning of all tendons has been completed and the total retained stress is equal to or exceeds that shown on the Drawings, as required for each member, and the steel strands or wires have been anchored, the annular space between the conduit and the tendons shall be grouted.

1102.06.2 Time of Grouting

Tendons shall be grouted within 7 days after tensioning and not before 12 hours after tensioning but only after the Engineer has given a written permission. The tendons shall be protected against corrosion by a plug at each end to prevent the passage of air, and such plugs shall be left in place until the tendon is grouted.

1102.06.3 Equipment

The grouting equipment shall include a mixer capable of continuous mechanical mixing which will produce a grout, free of lumps and undispersed cement. The equipment shall be able to pump the mixed grout in a manner which will comply with all provisions of these Specifications. Accessory equipment which will provide for accurate solid and liquid measures shall be provided to batch all materials. The pump shall be a positive displacement type . The pump shall have seals adequate to prevent introduction of oil, air and other foreign substance into the grout, and to prevent loss of grout or water.

The grouting equipment shall incorporate the following items :

a. A pressure gauge capable of being read to the nearest 1 kg/cm^2 which shall be placed at some point in the grout line between the pump outlet and the duct inlet.

b. A screen having clear openings of 3.2mm maximum size to screen the grout prior to its introduction into the grout pump. If a grout with a thixotropic additive is used, a screen opening of 4.8mm shall be allowed. The screen shall be easily accessible for inspection and cleaning.

c. The mixer must be kept at least partially full of grout at all times during the pumping operation to prevent air from being drawn into the post-tensioning duct.

   Under normal conditions, the grouting equipment shall be capable of continuously grouting the largest tendon on the project in no more than 20 minutes.

1102.06.4 Grout for Ducts

Grout shall be in accordance with Clause 1101.03.1 of these Specifications.

The proportions of materials used in the mix shall be based on tests made on the grout before grouting is begun, or may be selected on the basis of prior documented experience with similar materials and equipment and under comparable field conditions (weather, temperature etc.).

1102.06.5 Mixing of Grout

a. Water shall be added to the mixer first, followed by Portland cement and admixture (if any), or as may be required by the admixture manufacturer. Mixing shall be of such duration, with a minimum of 2 minutes, as to attain a uniform thoroughly blended grout without excessive temperature increase or loss of expansive properties of the admixture. The grout shall be continuously agitated until it is pumped.

b. Water shall not be added to increase grout flowability which has been decreased by delayed use of the grout.

1102.06.6 Flushing of Ducts

Flushing of metal ducts shall be by air and water. Water used for flushing ducts may contain slaked lime (calcium hydroxide) or quick-lime (calcium oxide) in the amount of 12 g per litre.

1102.06.7 Injection of Grout

All grout and high point vent openings shall be opened when grouting starts. Grout shall be allowed to flow from the first vent after the inlet pipe until any residual flushing water or entrapped air has been removed, at which time the vent should be capped or otherwise closed. Remaining vents shall be closed in sequence in the same manner.

The following procedures shall be used for the injection of grout:

a. The pumping pressure at the tendon inlet shall not exceed 17.6 kg/cm^2.

b. If the actual grouting pressure exceeds the maximum recommended pumping pressure, grout may be injected at any vent which has been, or is ready to be, capped as long as a one-way flow of grout is maintained. If this procedure is used, then the vent which is to be used for injection shall be fitted with a positive shut-off.

c. When one-way flow of grout cannot be maintained as outlined in the above paragraph, the grout shall be immediately flushed out of the duct with water.

d. Grout shall be pumped through the ducts and continuously wasted at the outlet pipe until no visible slugs of water or air are ejected and the efflux time of the ejected grout shall not be less than the injected grout. To ensure that the tendon remains, filled with grout, the outlet and/or inlet shall be closed. Plugs, caps or valves thus required shall not be removed or opened until the grout has set.

e. Grout temperature shall not be above 32°C during mixing or pumping. If necessary, the mixing water shall be cooled.

f. Grouted tendons or girders shall not be disturbed for 24 hours after grouting.

1102.07 PROTECTION OF END ANCHORAGES

As soon as possible after tensioning and grouting is completed, exposed end anchorages, wires and other metal accessories shall be cleaned of rust, misplaced mortar, grout and other such materials. A heavy, unbroken coating of epoxy bonding agent shall be applied to all such dry metal surfaces.

Tight fitting forms shall be installed and held in place securely against the previously placed concrete.

After application of the epoxy bonding agent, except where the protection will form the finished edge of the structure, a proprietary, pre-bagged, non-shrink, cementitious repair mortar shall be applied. The mortar shall be applied, finished and cured strictly in accordance with the manufacturer’s instructions.

Where the protection will form the finished edge of the structure the protection shall consist of concrete of the same quality and color as that of the adjacent visible part of the structure, applied and cured as specified in Section 5 (Concrete Works) of these Specifications.

1102.08 OPENING BRIDGES TO TRAFFIC

No equipment or vehicular traffic other than that authorized by the Engineer for the construction of the structure will be allowed on any bridge superstructure until the post-tensioning and grouting operation is completed, falsework has been removed, and all concrete and grout has gained the strength required in these Specifications, or as further directed by the Engineer.

1103 - PRE-TENSIONED CONCRETE CONSTRUCTION

1103.01 BEAMS MANUFACTURED OFF-SITE

The Contractor shall provide a suitable area to the approval of the Engineer within Kuwait which shall be designated as a part of the site for storage of the beams. Each beam will be deemed to have been delivered and will become the property of the Employer when it is complete to the satisfaction of the Engineer and has been stored in the designated area and marked clearly on an appropriate surface as the property of the Ministry of Public Works.

Arrangement of the beams in the store shall be to the approval of the Engineer.

1103.02 FORMWORK

1103.02.1 External

All external formwork shall consist of wrought formwork.

1103.02.2 Permanent Internal Formwork

Void formers shall be sufficiently robust to resist damage during concreting operations. Details of the permanent void formers shall be approved by the Engineer.

Void formers shall be adequately supported and anchored to the approval of the Engineer in such a way as to prevent flotation or displacement during concreting.

1103.03 CONCRETE WORK

1103.03.1 Concrete Placing

All structural concrete mixing, placement and curing shall be accomplished in shaded areas.

1103.03.2 Concrete Quality

Should any portion of the work prove, after removal of the formwork to be of inferior workmanship or to be in any way whatsoever defective, the beam or beams in question shall be broken up and disposed of immediately, except that, at the Engineer’s discretion, minor imperfections may be repaired,.

1103.03.3 Curing

All concrete shall be cured by being kept continuously moist for a period of at least 7 days after casting or until the concrete reaches the 28 day required test strength. Shorter periods may be approved by the Engineer with use of a suitable accelerated curing process. Curing shall be carried out in accordance with the requirements of Section 5 (Concrete Works) of these Specifications, and to the satisfaction of the Engineer.

1103.03.4 Accelerated Curing with Low Pressure Steam

Low pressure (atmospheric) steam curing shall be carried out within a suitable enclosure to contain the live steam and heat. The application of live steam shall not be directed on the concrete or the concrete forms. The enclosure shall contain suitable temperature measuring devices as directed by the Engineer. The temperature within the enclosure shall be maintained above 10^{o}C and not allowed to increase above 45^{o}C until the initial set

of the concrete has occurred. The time of initial set is defined as the time at which the strength of concrete cube(s) cured within the enclosure reach a strength equivalent to the 35 kg/cm^2 penetration resistance determined under ASTM C403. Following the time of initial set the temperature may be increased up to a maximum of 70^oC. The rate of temperature rise within the enclosure shall not exceed 20^oC per hour at any time. The maximum temperature shall be maintained until such time that, after a cooling down period of no more than 20^oC per hour, the concrete as determined from cubes within the enclosure can be expected to reach the strength indicated in the Drawings for detensioning. Detensioning shall be accomplished immediately after the accelerated curing is discontinued and the strength indicated in the Drawing is achieved.

After the detensioning operations are completed and the beam moved from the enclosure, the curing shall be continued in a manner approved by the Engineer, until the concrete meets its required 28 day working strength..

1103.03.5 Curing with Radient Heat

Accelerated curing with radiant heat may be applied by means of pipes circulating steam, hot oil or hot water, or by electric heating elements. The heating units or elements shall provide uniform distribution of heat without localized high temperatures. Radient heat curing shall be done under a suitable enclosure to contain the heat and moisture. Retention of moisture within the concrete is essential. All exposed concrete surfaces shall be covered as tightly as possible with plastic sheeting. The Engineer may direct an approved liquid membrane curing compound be applied to exposed concrete surfaces in addition to the plastic sheeting. The top surfaces of concrete to be used in composite construction shall be clear of residue at the time of erection. The remaining requirements for accelerated curing with radiant heat shall be specified above under curing with low pressure steam.

1103.04 STRESSING OPERATION

1103.04.1 Personnel

Prestressing operations shall be carried out only under the direction of an experienced and competent supervisor and all personnel operating the stressing equipment shall have been properly trained in its use. In addition to the normal precautions against accident which should be taken at all times for the whole of the Works, special precautions shall be taken when working with or near strands which have been tensioned or are in the process of being tensioned. All personnel engaged in stressing operations shall be subject to the approval of the Engineer.

1103.04.2 Components

Prestressing components shall be stored in clean dry conditions. They shall be cleaned and free from rust and mill scale at the time of fixing in position and subsequent concreting. There shall be no more rust on the steel than can be removed by wiping with clean cloths.

1103.04.3 Pretensioning Operation

a. The prestressing strands shall be accurately held in position and stressed by jacks. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units to permit access for cutting after the concrete has attained the required strength.

b. No bond stress shall be transferred to the concrete, nor shall end anchors be released, until the concrete has attained a compressive strength as shown by test cubes made and cured identically with the members of at least the minimum strength shown on the Drawings or in the Specifications for such transfer of load. The test cubes shall be made and tested in accordance with BSEN 12350 and BSEN 12390. The load shall be released gradually; strands shall be cut or released in such an order that eccentricity of prestress will be a minimum. They shall be cut in an order and in a manner approved by the Engineer.

c. Where strands are described in the Contract as debonded from the concrete, they shall be covered with sleeves of PVC or other material approved by the Engineer. The ends of the sleeves shall be taped to the strand to prevent the ingress of grout.

d. Members shall be free to accommodate the horizontal and vertical movements due to the application of prestress.

e. All members shall be indelibly marked to show the Member Mark as described in the Contract, the production line on which they were manufactured, the date on which the concrete was cast, the load applied

and, if they are of symmetrical section, the face which will be uppermost when the member is in its correct position in the works. The Markings shall be so located that they are not exposed to view when the member is in its permanent position.

f. Stressing of strands together with measurement of jacking pressures and extensions shall be performed in a manner similar to that required for post-tensioning tendons.

1103.05 STORAGE OF PRESTRESSED MEMBERS

When members are stored, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. When stacked upon one another, timber packings shall be used to separate the beams to prevent local crushing of concrete and to eliminate any twisting of the units.

1103.06 HANDLING AND PLACING OF PRESTRESSED MEMBERS

Members shall be handled and placed with minimum possible impact.

The lifting methods for all precast members shall be to the approval of the Engineer, and the Contractor shall submit details of any hooks or lifting eyes he proposes to cast into the members. Such details should include proposals for cutting the eyes or hooks from the precast members, including the provision of sufficient cover to the remaining embedded steel, and the restoration of the surface.

1103.07 TOLERANCE

The manufacturing tolerance for the precast members shall nowhere exceed those given for length, cross-section and straightness in British Standard Code of Practice CP116 : The Structural use of Precast Concrete.

1103.08 MANUFACTURE OF PRESTRESSED MEMBERS

The details of the method of manufacture shall be approved by the Engineer before work is started. When the method has been approved no changes shall be made without the consent of the Engineer.

The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and the dates when tensioning of strands, casting of members and transfer of stress will be undertaken for the first time for each type of beam.

The Contractor shall send to the Engineer, not more than seven days after the transfer of stress, a certificate showing the force and strain in the strands immediately after they were anchored and the age in hours of the concrete at the time the stress was applied to the member. A copy of all twenty-eight day cube test results relating to the work shall be sent to the Engineer as they become available. Records shall be kept so that the identity of those who stress the strands, cast the concrete and transfer the stress, on any member or line of members can be traced.

1104 - MEASUREMENT AND PAYMENT

1104.01 POST-TENSIONED CONCRETE

1104.01.1 Concrete Method of Measurement and Basis of Payment

Concrete in post-tensioned concrete works shall be measured and paid for in accordance with Clause 504.08 of these Specifications. Payment shall be made under Section 11 of the Bills of Quantities

1104.01.2 Reinforcing Steel Method of Measurement and Basis of Payment

Reinforcing steel in post-tensioned concrete works shall be measured and paid for in accordance with Clause 504.02.8 of these Specifications. Payment shall be made under Section 11 of the Bills of Quantities.

1104.01.3 Prestressing Steel Method of Measurement and Basis of Payment

Prestressing steel shall be measured by the weight in metric tonnes for each size and quality of wire, strands or bar furnished, installed, completed and accepted. The weight shall be calculated based on the nominal mass of

each diameter wire, strand or bar as stated in the standards listed in Clause 1101.01.1 of these Specifications.

The prestressing steel shall be measured as the actual length between the outermost surfaces of the anchorages except where couplers are used in which case, the prestressing steel shall be assumed to be continuous, without any flares, through the coupler.

Items not measured: Measurement of prestressed concrete is restricted to the items stated in Clauses 1104.01.01, 02 and 03 of these Specifications. No separate measurement is made for any other component or work required or listed below:

i. Cable ducts, duct couplers, grout tubes and steel chairs for the correct duct/tendon location.

ii. Prestressing steel used in connection with temporary works is not measured for payment even if such steel is left permanently in the member.

iii. Epoxy bonding agent used in precast segmental construction.

iv. Shear keys and location dowels used in precast segmental construction.

v. Prestressing steel and anchorages used for applying temporary prestress to glued segments.

vi. Anchorages and couplers.

The amount of completed and accepted work measured as provided for above shall be paid at the rates in the Bills of Quantities. These rates shall be full compensation for the provision of materials, equipment, labor, tools, testing and other items necessary for proper completion of the Work. The rates shall include:

i. Items not measured as described above.

ii. Cement, water and additive used in making the grout.

iii. All prestressing equipment and its calibration.

iv. Plant, equipment and labor for all stressing and grouting operations, including making good all anchorage pockets as shown on the Drawings or as directed by the Engineer.

v. All testing required in the Specifications.

1104.01.4 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1104.1.1	Concrete (prestressed) (class) (type) (location instructure) (finish)	cu.m.
1104.1.2	Mild steel bar reinforcement of any diameter	t.
1104.1.3	High tensile steel bar reinforcement of any diameter (grade)	t.
1104.1.4	Fabric wire mesh reinforcement of any size	t.
1104.1.5	Prestressing wires (size and type)	t.
1104.1.6	Prestressing strands (size and type)	t.
1104.1.7	Prestressing bars (size and type)	t.

1104.02 PRECAST BEAMS (Pre-Tensioned and /or Post-Tensioned)

1104.02.1 Method of Measurement and Basis of Payment

Measurement of concrete bridge beams shall be by type and number based on the length of the beams measured on the concrete line.

Measurement shall be for:

a. Manufacture of precast beams
b. Delivery of precast beams
c. Erection of precast beams

Payment for the manufacture of precast beams shall be at the rate entered in the Bills of Quantities which rate shall be deemed to include providing all labour, materials, plant and equipment required for the beam manufacture including furnishing and placing of reinforcing steel, prestressing steel, anchorages, ducts, concrete, formwork, providing materials samples for testing, carrying out testing (except load testing of the beams) and all necessary storage of beams prior to delivery.

No payment for manufacture of beams will be considered for beams partly completed. Payment will only be made on the approval of the Engineer for those beams fully completed and delivered to store.

Payment for delivery of precast beams shall be at the rate entered in the Bills of Quantities which rate shall be deemed to include providing all labour, materials, plant and equipment required for the collection and delivery to the works of precast beams and all necessary storage of the beams after delivery to sites and up to the time of erection.

Payment for erection of beams shall be at the rate entered in the Bills of Quantities which rate shall be deemed to include providing all labour, materials, plant and equipment required for the erection of precast beams.

The rates shall include for all or any additional insurances as may be required in respect of handling, transporting, storing or erecting of the beams.

1104.02.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1104.2.1	Manufacture of precast prestressed concrete beams (type) (length)	nr.
1104.2.2	Delivery of precast prestressed concrete beams (type) (length)	nr.
1104.2.3	Erection of precast prestressed concrete beams (type) (length)	nr

SECTION 12: METAL WORKS

1200 - GENERAL

1200.01 SCOPE

This Section contains specifications for metal work which consists of furnishing, fabricating, transporting, erecting and painting steel structures or structural steel portions of structures, including steel beams, steel sign support structures, steel grillage, steel columns, posts and all other steel shapes and items including those steel items embedded in concrete; railing work; fencing; all other metal work in accordance with these Specifications and in conformity with the Drawings.

Equivalent materials to other recognized standards may be substituted with the approval of the Engineer.

1201 - MATERIALS AND TESTING

1201.01 STANDARD AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section

ASTM

A 36 M	Structural Steel
A 53 M	Pipe, Steel, Block and Hot Dipped, Zinc Coated, Welded and Seamless
A 123 M	Zinc (Hot Galvanized) Coating on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strips
A 143 M	Safeguarding Against Embrittlement of Hot Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
A 153 M	Zinc Coating (Hot Dip) On Iron and Steel Hardware
A 193 M	Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service
A 194 M	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
A 240 M	Heat Resisting Chromium and Chromium Nickel Stainless Steel Plate, Sheet and Strip for Fusion Welded Unfired Pressure Vessels
A 242 M	High Strength Low Alloy Structural Steel
A 307	Carbon Steel Externally and Internally Threaded Standard Fasteners
A 325 M	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
A 384 M	Safeguarding Against Warpage and Distortion during Hot Dip Galvanizing of Steel Assemblies
A 385	Providing High Quality Zinc Coatings (Hot Dip) on Assembled Products
A 449	Standard Specification for Hex Cap Screwa, Bolts and Studs, Steel, Heat Treated
A 490 M	Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
A 505	General Requirements for Steel Sheet and Strip
A 563 M	Carbon and Alloy Steel Nuts
A 572	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
A 576	Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
A 606	Steel Sheet and Strip, High Strength
A 668 M	Steel Forgings, Carbon and Alloy, for General Industrial Use
B 26 M	Aluminum – Alloy Sand Castings
B 108	Magnesium Alloy Extruded Bars, Rods, Shapes, Tubes and Wire
B 117	Standard Practice for Operating Salt Spray (Fog) Apparatus
B 209 M	Aluminum Alloy Sheet and Plate
B 211 M	Aluminum Alloy Bars, Rods and Wire
B 221 M	Aluminum Alloy Extruded Bars, Rods, Wire Shapes and Tubes
B 633 M	Electro-deposited Coatings of Zinc on Iron and Steel
C 109	No Shrinkage Grout
D 13	Turpentine Ingredients

D 79	zinc Oxide
D 80	Leaded Zinc Oxide
D 81	Basic Carbonate White Lead
D 82	Basic Sulphate White Lead
D 83	Red lead
D 185	Coarse Particles
D 209	Lampblack
D 211	Medium Chrome
D 234	Raw Linseed Oil Ingredients
D 235	Mineral Spirits
D 260	Boiled Linseed Oil Ingredient
D 476	Titanium Dioxide
D 478	Zinc Chromate
D 480	Aluminum Paste
D 521	% of Total Solid by Weight
D 561	Carbon Black
D 562	Viscosity Test
D 600	Liquid Paint Driers
D 604	Diatomaceous Silica
D 605	Magnesium Silicate
D 607	Mica, Water Ground
D 838	Refined Solvent Naptha
D 846	Xylene
D 963	Phthalocyanine Blue
D 1199	Calcium Carbonate
D 1210	Fineness of Grind
D 1475	Density Test
D 1499	Operating Light and Water Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastic
D 1640	Drying Test
D 1648	Basic Lead Silico-Chromate
D 2369	% of Total Solids by Weight
D 2371	% of Pigments
D 2621	Infrared Analysis
D 2698	% of Pigments (Super Centrifuge Method)
D 3359	Adhesion Test
D 3722	Red and Brown Iron Oxide
D 3723	% of Pigments (Ignition Method)
D 3960	% of Total Solid
D 4017	% of Water
D 4400	Wet Film Thickness
E 42	Plasticized Polyvinyl Chloride
E 94	Radiographic Inspection
E 164	Standard Practice for Contact Ultrasonic Testing of Weldments
E 165	Liquid Penetration Test
E 350	Method for Chemical Analysis of Carbon Steel, Alloy Steel, Iron and Wrought Iron
E 709	Magnetic Particle Test
E 1806	Method, Sampling Steel and Iron for Determining Chemical Composition
F 436 M	Hardened Steel Washers
F 959 M	Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners
G 152	Non-Metallic Materials Exposure Tests

AASHTO

M 67	Foliage Green Bridge Paint
M 69	Aluminum Paint
M 70	White and Tinted Ready-Mix Paint
M 72	Red Lead Ready Mixed Paint
M 111	Zinc (Hot Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bar and Strip

M 133	Preservatives and Pressure Treatment Process for Timber
M 160	General Requirements for Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use
M 164	High-Strength Bolts for Structural Steel Joints, Including Suitable Nuts and Plain Hardened Washers
M 168	Wood Products
M 180	Corrugated Sheet Steel Beams for Highway Guardrail
M 181	Chain Link Fence
M 183	Structural Steel
M 193	Cast Aluminum Railway Posts

AWS

A 5.1 A	Welding Electrodes
D 1.5	Bridge Welding Code
5.5 A	Welding Methods
5.17 A	Welding Electrodes
5.18 A	Welding Electrodes
5.28 D	Welding Methods
1.1 D	Welding Methods
2.0 D	Welding Methods
4.4-82	Welding Methods

ANSI

B 1.13 M	Threaded Parts
B 18.2	Regular Semi-Finished Hexagon Bolts
B 18.23.1	Washers

FEDERAL SPECIFICATIONS

FF-P-101E	Heavy Duty Padlocks
RR-W-410F	Wire Rope and Strand
TT-D-643	Lead / Manganese /Cobalt Napthenate
TT-D-651	Liquid dryer
TT-L-215	Raw Linseed Oil
TT-N-95	Thinner (Naptha)
TT-P-347	Chromium Oxide
TT-P-403	Magnesium Silicate
TT-P-408	Red Iron Oxide
TT-P-442	Titanium Dioxide
TT-P-463	Zinc Oxide
TT-P-615	Basic Lead Silico-Chromate
TT-P-641	Zinc Dust – Zinc Oxide Paint
TT-R-266	Resin Alkyd Solutions
TT-R-291	Mineral Spirits
TT-T-775	Raw Tung Oil Ingredient

AWWA

C203	Standard for Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied

AISI

C 1035	Standard Grade Carbon Steel

SAE

C 25	Grit for Shot Blasting
S 330	Shot for Shot Blasting

AWPA

C 1 Pentachlorophenol Timber Treatment
C 14 Pentachlorophenol Timber Treatment
P 8 Pentachlorophenol Timber Treatment

U.S. Dept of Transport Research Circular No. 191

U.S. Dept of Transport Research Circular No. NCHRP 350

BS

BS EN 1317-3:2000 Road restraint systems. Performance classes, impact test acceptance criteria and test methods for crash cushions

DIN

54120 Lamination test

STEEL STRUCTURE PAINTING COUNCIL

Paint Specification No 16 - Coal - Tar Epoxy Polynide Black Paint

U.S. CORPS OF ENGINEER SPECIFICATIONS

Formula C - 200A - Coal - Tar Epoxy Paint

1201.02 STRUCTURAL STEEL

All structural steel shall be new and shall conform to the following specifications:

a. Unless otherwise shown on the Drawings, structural carbon steel shall conform to the specification for steel for bridges and buildings of ASTM A36M (AASHTO- M183).

b. Unless otherwise shown on the Drawings, high strength steel bolts and washers shall conform to ASTM A325M. All high strength nuts shall be of such capacity to develop the bolt strength.

c. Unless otherwise shown on the Drawings, steel anchor bolts, nuts and washers and assembly bolts, nuts and washers for round tube post bases shall be to ASTM A307.

d. Unless otherwise shown on the Drawings, steel bolts, nuts and hardened washers shall be galvanized in accordance with ASTM A153M.

e. Structural steel shall not be obtained from stock except with the express permission of the Engineer.

f. Steel for lighting poles and masts shall be as specified in Section 14 (Lighting and Electrical Works) of these Specifications.

g. Where specified, load indicating washers shall conform to ASTM F 959M

1201.03 STEEL FORGINGS

Steel forgings shall be as shown on the Drawings and shall conform to ASTM A668M, Class F.

1201.04 STEEL PIPE

Unless otherwise shown on the Drawings, steel pipe shall conform to ASTM A53M (under 101.6 mm OD, Type F; 101.6 mm OD and over, Type E and S, Grade B), and other structural steel shall conform to ASTM A36M.

Friction caps shall be as follows:

a. Caps shall be manufactured from either hot rolled or cold rolled steel sheets. The minimum sheet metal thickness shall be 24 gauge.

b. The rim edges shall be reasonably straight and smooth. Caps shall be sized and formed in such a manner as to produce a drive-on friction fit and have no tendency to rock when seated on the pipe. The depth shall be sufficient to give positive protection against the entrance of rainwater or sand. Caps shall be free of sharp creases or indentations and show no evidence of metal failure.

c. Caps shall have an electro-deposited coating of zinc in accordance with the requirements of ASTM B633M.

1201.05 GALVANISING

Galvanizing shall be by the hot dip process in accordance with ASTM A123M, unless otherwise specified.

The galvanized coating shall be uniform in appearance and color when the galvanized surfaces are not to be painted.

All fabrication shall be completed and ready for assembly before galvanizing. No punching, drilling or cutting shall be permitted after galvanizing.

Precautions shall be taken against embrittlement, warpage and distortion in accordance with ASTM A143M and ASTM A384M.

1201.06 ALUMINUM FOR SIGNS

All Aluminum shapes and materials shall be new and shall conform to the following requirements :

a. Extruded Aluminum shapes for panels and mouldings shall conform to the requirements for Aluminum alloy ASTM B221M, Alloy 6063-T6.

b. Aluminum alloy sheet and plate shall conform to ASTM B209M, Alloy 6061-T6.

c. Panel bolts and post clip bolts shall be made from Aluminum alloy ASTM B211M, Alloy 2024-T4. Thread fit for bolts shall conform to American Standards Association Class 2A. All Aluminum bolts shall have an anodic coating of 0.005mm minimum thickness with dichromate or boiling water seal.

d. Aluminum Nuts, 6mm tap and under, and all bolts and machine screws shall be made from Aluminum alloy ASTM B211M, Alloy 2024-T4. Nuts 8 mm tap and over shall be Aluminum alloy ASTM B211M, Alloy 6262-T9.

   The thread fit for bolts and machine screws shall conform to American Standards Association Class 2A and the thread fit for the nuts shall be Class 2B. All nuts, 6 mm tap and under, bolts and machine screws shall receive an anodic coating of 0.005 mm minimum thickness with dichromate or boiling water seal.

e. Flat washers for Aluminum bolts and post clips shall be 10 mm ID x 19.0 mm OD x 2.3 mm and shall be made from Aluminum alloy ASTM B209M, Alloy 2024-T4.

f. Lock nuts shall be Aluminum alloy, ASTM B211M, Alloy 2017-T4, and shall have an anodic coating of 0.005mm minimum thickness with dichromate or boiling water seal. Thread fit for lock nuts shall be as

recommended by the manufacturer. Aluminum spring-lock washers shall be made from Aluminum alloy ASTM B211M, Alloy 7075-T6.

g. Extruded Aluminum sign brackets for tubular posts shall be Aluminum alloy ASTM B221M, Alloy 6062-T6.

h. Sand-cast Aluminum mounting brackets shall be Aluminum alloy 356-T6, ASTM B26M, Alloy SG70A-T6.

i. Cast post clips shall be Aluminum alloy 356-T6, ASTM B108, Alloy SG70G-T6.

j. Side trim shall be Aluminum alloy, ASTM B221M, Alloy 6063-T6.

1201.07 STORAGE OF MATERIALS

All structural steel work and Aluminum work as specified herein and as shown on the Drawings shall be stored above the ground on platforms, skids or other supports. All metal materials shall be kept free from dirt, grease and other foreign matter and shall be protected from corrosion.

1201.08 TRANSPORTING MATERIALS

All structural steel work and Aluminum work as specified herein and as shown on the Drawings shall be transported and protected during all handling to prevent distortion, deformation or damage of any kind. Any metal materials damaged during transportation, handling or otherwise shall be rejected and the Contractor shall provide new material as required and at no additional expense to the Employer.

1202 - STRUCTURAL STEEL FABRICATION

1202.01 GENERAL REQUIREMENTS

All structural steel work for sign support structures and other work as shown on the Drawings shall conform to the following requirements:

a. Rolled material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends shall be cause for rejection of the material.

b. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting and chipping shall be done carefully and accurately.

c. All connections shall be with high strength bolts and as shown on the Drawings and as approved by the Engineer. Except for connections using high-strength bolts tightened to a high tension as specified in Clause 1202.02 of these Specifications the following general requirements shall apply:

   i. Bolt types shall be as shown on the Drawings.. Bolted connections shall be used only as indicated by the Drawings or as specified. Unless otherwise shown on the Drawings, bolts shall have single self-locking nuts or double nuts. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

   ii. Unfinished bolts shall be standard bolts (ordinary rough or machine bolts).

   iii. Holes for turned bolts shall be carefully reamed and the bolts turned to a light driving fit with the threads entirely outside of the holes and a washer shall be used. Turned bolts shall be finished by a finishing cut. Heads and nuts shall be hexagonal.

   iv. Ribbed bolts shall make a driving fit with the holes. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversize bolt used as a replacement. Nuts shall be hexagonal.

1202.02 CONNECTIONS USING HIGH-TENSILE STRENGTH BOLTS TIGHTENED TO A HIGH TENSION

1202.02.1 General

This Specification covers the assembly of structural joints using ASTM A325 or other high strength steel bolts tightened to a high tension. The bolts are used in holes slightly larger than the normal bolt size.

1202.02.2 Materials

a. General – Unless otherwise shown on the Drawings, bolts, nuts and washers shall conform to requirements of the current edition of ASTM A 325M.

b. Bolts - Unless otherwise shown on the Drawings, bolt dimensions shall conform to the current requirements of ANSI B 18.2.3.7M for full body, heavy hex structural bolts. Threads shall be Metric Coarse Thread Series as specified in ANSI B 1.13M and, except for zinc coated bolts and nuts, shall have grade 6g tolerances. Threads for zinc coated bolts and nuts may exceed the grade 6g limits by the amount specified in Clause 7.3 of ASTM A325M.

c. Nuts – Unless otherwise shown on the Drawings, nuts shall conform to the requirements of ASTM A563M, heavy hex, and shall be of the class and surface finish for each type of bolt as follows:

Bolt Type and Finish	**Nut Class and Finish**
1 and 2, plain, (uncoated)	8S or 8S3, plain
1 and 2, zinc coated	10S, zinc coated
3, plain	8S3, plain

d. Washers – Circular washers shall be flat and smooth, and their nominal dimensions shall not be less than those given in Table 1202.02.2. Beveled washers shall be square or rectangular, taper in thickness, and conform to the dimensions given in the Table 1202.02.2.

When necessary, washers may be clipped on one side to a point not closer than 7/8 of the bolt diameter from the center of the washer.

Circular Washers				**Square or Rectangular Washers**		
Bolt Size mm	Inside Dia. mm min-max	Outside Dia. mm Min-max	Nom. Thick mm min-max	Width mm min	Mean Thickness mm	Taper
12	14.0 - 14.4	25.7 - 27.0	3.1 - 4.6	45	8	To suit Flange
14	16.0 - 16.4	28.7 - 30.0	3.1 - 4.6	45	8	To suit Flange
16	18.0 - 18.4	32.4 - 34.0	3.1 - 4.6	45	8	To suit Flange
20	22.0 - 22.5	40.4 - 42.0	3.1 - 4.6	45	8	To suit Flange
22	24.0 - 24.5	42.4 - 44.0	3.4 - 4.6	45	8	To suit Flange
24	26.0 - 26.5	48.4 - 50.0	3.4 - 4.6	45	8	To suit Flange
27	30.0 - 30.5	54.1 - 56.0	3.4 - 4.6	57	8	To suit Flange
30	33.0 - 33.6	58.1 - 60.0	3.4 - 4.6	57	8	To suit Flange
36	39.0 - 39.6	70.1 - 72.0	3.4 - 4.6	57	8	To suit Flange

Table 1202.02.2 – Washer Dimensions

1202.02.3 Installation

Surfaces of bolted parts in contact with the bolt and nut shall not have a slope of more than 1 : 20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Holes may be punched, sub-punched and reamed, or drilled, as required by the applicable specification and, unless shown otherwise on the Drawings, shall be of a nominal diameter not more than 1.5 mm in excess of the nominal bolt diameter.

When assembled, all joint surfaces, including those adjacent to the washers shall be free of scale except tight mill scale. They shall be free of dirt, loose scale, burrs, and other defects that would prevent solid seating of the parts.

Contact surfaces within friction-type joints shall be prepared as shown on the Drawings or in the Particular Specification.

Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening. A hardened washer shall also be used under the head of regular semi-finished hexagon bolts and under finished hexagon nuts, even when these are not the elements turned in tightening. The washer may be omitted under the head of heavy semi-finished hexagon bolts and interference-body bolts and under heavy semi-finished hexagon nuts, when these are not the elements turned. A flat washer may be used when the abutting surface adjacent to the bolt head or nut does not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for lack of parallelism.

1202.02.4 Minimum Bolt Tension

a. General – All fasteners shall be tightened to give at least the required minimum bolt tension values in accordance with AASHTO Standard Specifications for Highway Bridges. Tightening shall be done with properly calibrated wrenches, by the turn of nut method or by use of a load indicating fastener system.

b. Inspection and Testing – The Engineer shall satisfy himself that all requirements of these Specifications are met.

The Engineer shall approve the procedures for calibrating wrenches and for the installation of bolts, and shall observe the field installation to determine that these procedures set herein are followed.

Spot checks shall be made with a manual torque wrench that has been calibrated as previously specified herein.

1202.03 FABRICATION OF PLATES

Sheared edges of plates more than 15 mm in thickness and carrying calculated stress shall be planed to a depth of 6mm. Re-entrant cuts shall be filleted before cutting.

1202.04 SHOP COMPONENTS

All shop components shall be cambered and dimensioned as shown on the Drawings or as directed by the Engineer. Finished members shall be true to line and free from twist, bends and open joints.

1202.05 ROLLED STEEL PLATES

Cold-bent load-carrying rolled steel plates shall conform to the following:

a. They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling.

b. The radius of bends, measured to the concave face of the metal, shall not be less and preferably shall be greater than:

61 degrees to 90 degrees	1.0T
91 degrees to 120 degrees	1.5T
121 degrees to 150 degrees	2.0T

T = thickness of the plate

c. Before bending, the edges of the plate shall be rounded to a radius of 1.5 mm throughout that portion of the plate at which the bending is to occur.

1202.06 PINS

Pins shall be accurately turned to the dimensions shown on the Drawings and shall be straight, smooth and free from flaws.

Material for the manufacture of pins shall be as shown on the Drawings.

1202.07 SHOP WORK

1202.07.1 Notice of Work

The Contractor shall give the Engineer ample notice of the beginning of work in the shop, so that inspection may be provided.

1202.07.2 Inspection

The Contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and the inspectors shall be allowed free access to the necessary parts of the work.

Inspectors shall have the authority to reject any material or work which does not meet the requirements of these Specifications. In case of dispute the Contractor may appeal to the Engineer, whose decision shall be final.

1202.07.3 Mill Orders and Certificates

The Contractor shall furnish the Engineer with as many copies of mill orders as the Engineer directs and shall also provide original or certified copies of all mill certificates issued.

1202.07.4 Identification

Each member shall be painted or marked with an erection mark for identification and an erection diagram shall be furnished with erection marks shown thereon. Members shall also be properly marked to indicate the type of steel.

The Contractor shall furnish to the Engineer as many copies of material orders, shipping statements and erection diagrams as the Engineer may direct.

1202.08 SHOP DRAWINGS

The Contractor shall furnish shop drawings as required by this Section of these Specifications and by the General Conditions.

1202.09 WELDING

1202.09.1 General

All welding shall be as shown on the Drawings and where directed by the Engineer. All welding shall conform to all requirements as specified herein.

1202.09.2 Materials

The following requirements for materials shall apply:

a. Before any electrodes or flux-electrode combinations are used for welding steel, the Contractor, at his expense, shall furnish certified copies of test reports for all the pertinent tests specified in AWS A5.1, A5.17 or A5.18, whichever is applicable, made on electrodes or flux-electrode combinations of the same class, size and brand as the electrodes to be used. If electrodes are to be used which are of a size for which tests are not required by the specifications governing the process applicable to those electrodes, the test reports shall be furnished for electrodes of the size nearest and of the same classification and brand as those to be used. The tests may have been made for process qualification or quality control, and shall have been made within one year prior to the manufacture of the electrodes and fluxes to be used. The report shall include the manufacturer's certification that the process and material requirements were the same for manufacturing the tested electrodes and the electrodes to be used. All pertinent information concerning the test required by the applicable electrode specifications shall be reported. The forms and certificates shall be as directed by the Engineer.

b. Electrodes for manual shielded metal arc welding of structural steel, ASTM A36, shall conform to the requirements of AWS A5.1 for E7015, E7016, E7018, or E7028 electrodes.

c. Electrodes and fluxes for automatic and semi-automatic submerged arc welding of structural steel, ASTM A36 shall conform to the requirements of AWS A 5.17 and AWS Flux Classifications F61-MLXXK or F62-MLXXK.

d. Solid and composite electrodes for automatic and semi-automatic gas metal-arc welding of structural steel, ASTM A36 shall conform to the requirements of AWS A 5.18 for E60S-2, E60S-3, E70S-6, E70T-1 or E70T-5 electrodes.

1202.09.3 Construction Requirements

Unless otherwise shown on the Drawings, work methods and procedures shall conform to the AWS/AASHTO D1.5 – Bridge Welding Code. except as modified by the requirements of these Specifications.

All welding shall be performed in such a manner that the Brinell hardness of the weld metal and heat-affected zone is within the following limits :

a. Minimum Brinell Hardness = (Minimum Specified Tensile Strength of Parent Metal) /500

b. Maximum Brinell Hardness = ((Max. Specified or Tested Tensile Strength of Parent Metal) /500) + 50

The minimum preheat and interpass temperatures for welding structural steel shall conform to Table 4, AWS 02.0, except that the minimum preheat for structural steel 19 mm or less in thickness, shall not be less than 10^{o}C.

Automatic vertical shielded metal-arc welding processes, such as electroslag or electrogas, may be used only on structural steel ASTM A36M. The impact strength requirements shall be included in the procedure qualification.

All welding shall be protected from air currents or drafts to prevent loss of heat or loss of arc shielding. The method of protecting the welding area from loss of heat or loss of arc shielding shall be subject to approval by the Engineer.

Areas contiguous to welding operations shall be preheated to a minimum temperature of 150°C when necessary, in the opinion of the Engineer, to prevent distortion or weld cracking. Preheating to a temperature in excess of 200°C will not be required

1202.09.4 Qualification of Welders

Welder qualification tests will be evaluated in accordance with requirements of the AWS.

In lieu of the AWS requirements, qualification tests for tack welding will be the same as the qualification tests required for butt welding material up to and including 18 mm thick.

1202.10 PAINTING

1202.10.1 Description

All painting work shall consist of preparing the surfaces, furnishing and applying paint to such structures or portions thereof that are designated to be painted as shown on the Drawings, as required by these Specifications and as directed by the Engineer. The Contractor shall include the protection from paint spatter and disfigurement of adjacent or nearby structures, and final clean-up, all in accordance with the General Conditions or as directed by the Engineer.

1202.10.2 Paint Systems

The paint system to be used shall be selected from one of those shown in Table 1202.10.2.1, taking into account the limitations of Table 1202.10.2.2.

The system shall be formulated to give a 'Time to First Maintenance' as shown in the Contract Documents, but in any case, this shall not be less than ten years.

Known incompatible coatings are shown in Table 1202.10.2.3.

1202.10. 3 Materials

a. All paint furnished must be shipped in strong, substantial containers, plainly marked with the name, weight, and volume of paint content, together with the color, formula, and the name and address of the manufacturer.

b. Paint shall be of the type shown on the Drawings or as specified herein.

c. Except as otherwise required in the cited specifications, all paint shall meet the following general requirements:

   i. The paint shall not show excessive settling in a freshly-opened full can, and shall easily be spread with a paddle to a smooth, homogeneous state. The paint shall show no curdling, livering, caking or color separation, and shall be free from lumps and skins.

   ii. The paint as received shall brush easily, possess good leveling properties, and show no running or sagging tendencies when applied to smooth steel vertical surfaces.

   iii. The paint shall not skin within 48 hours in a three-quarters filled closed container.

   iv. The paint shall dry to a smooth uniform finish, free from roughness, grit, unevenness, and other surface imperfections. The paint shall show no streaking or separation when flowed on clean glass.

   v. The paint shall show no thickening, curdling, gelling, or hard caking after six months storage in a full, tightly-covered container at a temperature of 21oC (70oF) to 32oC (90oF),

vi. All vehicles shall be free from rosin and rosin derivatives. They may contain addition agents such as anti-skinning and wetting aids.

vii. Where used, the following paint ingredients shall conform to the requirements of the specifications shown in Table 1202.10.3.

SYSTEM	PRIMER	INTERMEDIATE COAT	TOP COAT
1	IOZ	EP	APU
2	IOZ (WB)	ACR (WB)	ACR (WB)
3	PUZ	PU	APU
4	EPZ	EP	APU
5	EP	EP	APU
6	PUAL***	PU	APU
7	EM	EM	APU
8	OIL/ALK*	OIL/ALK*	OIL/ALK*
9	ACR (WB**)	ACR (WB**)	ACR (WB)**
10	PUMIOX***	PUMIOX	APU
11	PUZ	---	PUHB
12	PUZ	PU (WB)	APU (WB)
13	EPZ	ACR (WB)	ACR (WB)
14	TSZ	---	ACR (WB)
15	TSZ	---	---
16	EPPS	EM	ACREP

ACREP	Acrylic Epoxy
ACR	Acrylic Waterborne
ALM	Aluminum Mastic
APU	Aliphatic Polyurethane
EM	Epoxy mastic
EP	Epoxy
EPPS	Low Viscosity, 100% Solids, epoxy Penetrating Sealer
EPZ	Epoxy Organic Zinc Rich
IOZ	Inorganic Zinc Rich Primer
OIL/ALK*	Oil and Alkyd
PU	Polyurethane
PUAL***	Polyurethane Aluminum Primer
PUHB	Polyurethane, High Build
PUMIOX***	Polyurethane Micaceous iron oxide
PU (WB)	Polyurethane, water based
PUZ	Polyurethane organic Zinc Rich
TSZ	Thermal Sprayed Zinc

NOTES: *OIL/ALK Paints shall include alternative inhibitive pigments to lead, such as zinc oxide, barium metaborate, zinc hydroxyphosphate, calcium boro-silicate, calcium sulphanate, and zinc molybdate, which are acceptable alternatives.
**ACR (WB) paints are available with numerous resin systems and pigmentations ***PUAL and PUMIOX can be used as a primer on bare steel, or as a penetrating sealer on existing coatings. They should be formulated specifically for the intended use.

Table 1202.10.2.1 Paint Systems To Be Used On Steelwork

SYSTEMS IN TABLE 1 APPLICABLE TO NEW CONSTRUCTION OR TO MAINTENANCE PAINTING WHERE EXISTING PAINTS ARE COMPLETELY REMOVED	
Highly corrosive environment*	**Mildly corrosive environment**
1, 2, 3, 4, 10, 11, 13, 14, 15	1, 2, 3, 4, 5, 10, 11, 13, 14, 15

SYSTEMS IN TABLE 1 APPLICABLE TO MAINTENANCE PAINTING INVOLVING SPOT REPAIRS AND OVERCOATING**		
Existing paint system	**Highly corrosive environment**	**Mildly corrosive environment**
Zinc Rich	3, 4, 7, 9, 11, 12, 13, 16	3, 4, 5, 7, 9, 11, 12, 13, 16
Oil/Alkyd	6, 7, 8, 9, 10, 16	6, 7, 8, 9, 10, 16
Vinyl and Chlorinated Rubber	6, 9, 10	6, 9, 10
Epoxy or Polyurethane ***	5, 6, 7, 9, 10	5, 6, 7, 9, 10

NOTES: *A highly corrosive environment may be a 'macro' environment where high ambient chloride levels exist, such as over or adjacent to salt water, or a 'micro' environment, such as one where only a portion of a structure will be in contact with salt-laden water from leaking deck joints. All other environments are considered at least 'Mildly Corrosive'. **See below for notes regarding compatibility ***Roughening of existing surface is extremely important.
In all cases of over coating, it must be established that new coating system is compatible with the existing. In the following table incompatibilities are known.

Table 1202.10.2.2. Selection of Coating System

EXISTING PAINT TO BE COATED	KNOWN INCOMPATIBLE COATINGS	RESULT OF INCOMPATIBILITY
Zinc	Alkyds	Blisters or delaminates
Oil/Alkyd	Solvent-based Vinyls, Epoxies	Softens, lifts, or shrivels
Vinyl	Epoxies	Softens or dissolves coating

NOTES: 1) Where galvanized coatings are to be painted, the coating manufacturer's recommendations must be obtained and followed for pre-treatments, special primers etc.
2) These examples are a starting point for paint system selection. In all cases, the coating manufacturer should be consulted, and field trials carried out to determine compatibility.

Table 1202.10.2.3 Incompatible Coatings

1202.10.4 Data Sheets

The paint manufacturer shall provide all pertinent material, safety, and technical data sheets necessary for the proper and safe application of the product.

Data sheets shall contain, as a minimum, the following:

1. **The Properties of the materials, single or multiple compound**

a) Percentage of total solids by weight - ASTM D 2369 or, for zinc - ASTM D 2369 and D 521
b) Percentage of pigments by weight of total solids – ASTM D 2371
c) Percentage of resin components
d) Percentage of total solids by volume ASTM D 3960
e) Weight in kilograms per liter
f) Viscosity (Stormer) at 25^{o}C in Krebs Units (KU) – ASTM D 562
g) Pot life in hours at ___ ^{o}C and ___% Relative Humidity
h) Sag resistance (Lenata) in microns wet film thickness – ASTM D 4400

Raw Tung Oil	FS TT-T-775
Raw Linseed Oil	ASTM D 234
Boiled Linseed Oil	ASTM D 260
Turpentine (Gum spirits or Steam Distilled)	ASTM D 13
Alkyd resin	FS TT-R-266
Mineral Spirits	ASTM D 235
Thinner (Naptha, Low-Boiling)	FS TT-N 95 (Type 1)
Lead Napthenate	FS TT D 643
Manganese Napthenate	FS TT D 643
Cobalt Napthenate	FS TT D 643
Liquid Dryer	FS TT-D 651
Driers	ASTM D 600
Titanium Dioxide	ASTM D 476
Red Lead (95% grade)	ASTM D 83
Basic Carbonate White Lead	ASTM D 81
Leaded Zinc Oxide (1)	ASTM D 80
Basic Sulphate White Lead	ASTM D 82
Basic Lead Silico-Chromate Chromate	ASTM D1648
Red and Brown Iron Oxide	ASTM D 3722
Magnesium Silicate * (Except Fe_2O_3 shall be less than 0.4% and R_2O_3 Shall be less than 3.	ASTM D 605*
Carbon Black	ASTM D 561
Lampblack	ASTM D 209
Medium Chrome Yellow, and Orange	ASTM D 211
Zinc Chromate	ASTM D 478
Zinc Oxide (American Process)	ASTM D 79
Mica, Water Ground, 45µ Sieve	ASTM D 607
Red Iron Oxide, 82 to 85%	FS TT-P 408
Chromium oxide	FS TT-P-347
Phthalocyanine Blue	ASTM D963
Zirconium Complex, Dryer Catalyst, 6% titanium Dioxide,	FS TT-P 442
Calcium Carbonate	ASTM D 1199 (Type GC)
Diatomaceous Silica	ASTM D 604 (Type A)
Refined Solvent Naptha	ASTM D 838
Xylene	ASTM D 846
Organo-mont-morillonite : Shall be a fine, creamy white powder, with high gelling efficiency in a wide range of organic liquids, with water content of less than 3% and fineness of less than 5% retained on the No.200 sieve (75 micron).	
Note: FS = Federal Specification The manufacturer may, at his option, blend normal or basic lead sulphate with zinc oxide to provide, in the finished paint, the leaded zinc oxide required in ASTM D 80	

Table 1202.10.3 Paint Ingredients

i) Recommended maximum and minimum DFT in microns
j) Theoretical coverage in microns/m^2/liter
k) Minimum drying time at 24°C and 50% relative humidity – ASTM D1640
   i. To touch
   ii. To handle
   iii. To overcoat
l) Mixing ratio for multiple component coatings
m) Shelf life for each component when stored at 24°C
n) Infrared analysis – ASTM D2621
   i. Zinc primer coats, infrared spectrum (2.5 to 15 microns) of the vehicle component.
   ii. Two component topcoats, infrared spectrum (2.5 to 15) microns of each single component and also of the mixed components (when applicable) in appropriate mixing ratios.
o) Zinc content, percentage by weight of DFT – ASTM D 2371 and ASTM D 521
   i. Inorganic zinc – 74 percent minimum
   ii. Organic zinc – 77 percent minimum
p) Total zinc, metallic zinc and zinc oxide, percentage by weight of pigment(zinc dust) – ASTM D 521

2. Application Information

a) Minimum surface preparation requirements for each intended coat.
b) Ambient temperature, surface temperature, material temperature, and humidity requirements for application.
c) Requirements for application by spray, roller or brush.
d) Maximum ratio of designated thinner that can be added to the single or mixed components of the coating.
e) Mixing

3. Health and Safety Data Sheets, giving, as a minimum:

a) Manufacturer and product identification information
b) Hazardous ingredients, with maximum occupational exposure limits.
c) Health hazard information, including effects on humans and symptoms of over exposure.
d) Fire and explosion data including flash point, flammable limits, extinguishing media and any special fire fighting procedures.
e) Conditions to be avoided when using the product.
f) Spill or leak procedures, including waste disposal method.
g) Safe handling and use information, including eye and skin protection, respiratory and ventilation requirements, hygienic practices, and protective measures during repair and maintenance of contaminated equipment
h) Emergency procedures for contact with eyes and skin, and inhalation and ingestion.
i) Storage data and any other special precautions required.

1202.10.5 Sampling and Testing

Sampling and Testing – Unless otherwise specified, sampling and testing will be performed in accordance with Federal Test Standard No.141 or ASTM Standards as follows:

Test Method

Percentage of pigment by weight (Extraction Method)	ASTM	D 2371*
Density	ASTM	D 1475
Volatile and Non-volatile content	ASTM	D 2369 or D 3723
Consistency (Viscosity): Krebs-Stormer	ASTM	D 562
Coarse particles	ASTM	D 185
Sampling and Testing for Flaked Aluminum Powders and Pastes	ASTM	D 480
Fineness of grind	ASTM	D 1210
Isolation of vehicle	ASTM	D2698
Adhesion	ASTM	D3359, Method A
Percent Water	ASTM	D 4017
Infrared Spectrum of Vehicle Solids	ASTM	D 2621
Contractor Inspection Responsibility	FTS	1031.1
Application of Sprayed Films	FTS	2131.2
Condition in container	FTS	3011.3
Storage stability	FTS	3022.2
Non-Volatile vehicle content	FTS	4053.2
Drying Time	FTS	4061.3
Reducibility and Dilution stability	FTS	4203.2
Color Specification from Photometric Tristimulus Data	FTS	4252.1
Appearance of Transparent Liquids	FTS	4261.1
Brushing Properties	FTS	4321.3
Spraying properties	FTS	4331.2
Infrared Reflectance from Spectrophotometric Data	FTS	6241.2
Infrared Reflectance from Reflectometer	FTS	6242.2
Adhesion (Wet) Tape Test	FTS	6301.3
Knife Test	FTS	6304.2

*Supercentrifuge method - follow ASTM D2698. Ignition method – follow ASTM D3723

1202.10.6 Preparing Metal Surfaces for Painting

Surfaces of metal to be painted, including galvanized surfaces, shall be thoroughly cleaned to the condition specified in these Specifications by removing rust, loose mill scale, welding slag, dirt, oil, grease, and other foreign substances. Unless provided otherwise on the Drawings or in these Specifications, the Contractor may use any of the following methods:

a. "Method A", Solvent Cleaning – It is intended that solvent cleaning shall be used prior to the application of paint, and with other methods of surface cleaning.

   Soil, cement spatter, drawing compounds, salts, soluble welding flux residues, and other foreign matter (other than grease or oil) shall be removed by cleaning with solutions of alkaline cleaners, and brushing with stiff fiber or wire brushes, or by scraping, or by cleaners and shall be followed by a fresh water rinse, or by a combination of these methods.

   Oil or grease shall be removed by any of the following methods:

   Wiping or scrubbing the surface with rags or brushes wetted with solvent.

   Spraying of the surface with solvent. The final spraying shall be done with clean solvent.

   Vapor degreasing, using stabilized chlorinated hydrocarbon solvents.

Complete immersion in a tank or tanks of solvent.

Emulsion cleaners or steam cleaning may be used in place of the methods above, provided that after treatment the surface shall be washed with hot water to remove detrimental residue.

b. "Method B", Hand Cleaning – After oil, grease, soluble welding flux residues, or salts are removed by methods prescribed under "Method A", loose mill scale, loose rust, and other detrimental foreign matter shall be removed by hand brushing, hand sanding, hand scraping, hand chipping, hand hammering, or other methods using hand impact tools, or by a combination of these methods.

All accessible weld flux and spatter shall be removed by hand scraping or by hand impact tools followed by wire-brushing.

Areas which will be inaccessible after assembly shall be cleaned before assembly.

All bolts, welds, corners, joints, and openings shall be properly cleaned. The steel wires of the wire brushes shall have sufficient rigidity to clean the surface, shall be kept free of excess foreign matter, and shall be discarded when they are no longer effective. Hand scrapers shall be kept sharp enough to be effective. The tools shall be operated in such a manner that no burrs or sharp ridges are left on the surface and no sharp cuts made into the steel.

After hand cleaning is completed, dust and other loose matter shall be removed from the surface. Detrimental amounts of grease or oil still present shall be spot cleaned with solvent.

c. "Method C", Power Tool Cleaning – After oil, grease, soluble welding flux residues, or salts are removed by the methods prescribed under "Method A", loose mill scale, loose rust, weld flux, and spatter shall be removed with power wire brushes, power impact tools, power grinders, power sanders, or by any combination of these methods.

Power wire brushes shall be of the rotary cup type of suitable size for entering all accessible openings, angles, joints, and corners. The steel wires of such brushes shall have sufficient rigidity to clean the surface, shall be kept free of excess foreign matter, and shall be discarded when they are no longer effective.

Power impact tools shall include power-driven chipping or scaling hammers, rotary scalers, single or multiple pistons scalers, or other similar impact cleaning tools. Cutting edges of all tools shall be kept in effective condition.

Sanding or abrasive materials used in power sanding shall be discarded when they become ineffective.

Rivet heads, cracks, crevices, lap joints, fillet welds, and re-entrant angles shall be cleaned by the use of power wire brushes, sharp chisels used in chipping or scaling hammers, rotary grinders, or sanders, or by a combination of such tools.

All tools shall be operated in such a manner that no burrs or sharp ridges are left on the surface and no sharp cuts are made into the steel. Areas inaccessible for cleaning by power tools but accessible for hand cleaning shall be cleaned by methods outlined under "Method B".

After these cleaning operations are completed, dust and other loose matter shall be removed from the surface. If detrimental amounts of grease or oil are still present, these areas shall be spot cleaned with solvent.

d. "Method D", Blast Cleaning – After heavy deposits of oil, grease, soluble welding flux residues, or salts are removed by the methods prescribed under "Method A", loose mill scale, rust-scale, and other foreign matter shall be removed and the entire surface thoroughly cleaned by blasting except that excessive rust-scale shall, preferably, be removed by impact tools, as prescribed under "Method B" and "Method C". Any of the following blast cleaning methods may be used:

Dry sandblasting, using compressed air blast nozzles and dry sand, crushed garnet, crushed olivine, or other suitable mineral.

Wet or water-vapor sandblasting, using compressed air blast nozzles and water and sand, crushed garnet, crushed olivine, or other suitable mineral.

Grit-blasting, using compressed air blast nozzles and grit made of crushed cast iron, malleable-iron, steel, or other metals.

Shot blasting, using compressed air nozzles and cast-iron, malleable-iron, or steel pellets.

Closed, recirculating nozzle-blasting, using compressed air or vacuum with any of the above named abrasives.

Grit-blasting, using centrifugal wheels and grit made of crushed cast-iron, malleable-iron, steel, or other metals.

Shot-blasting, using centrifugal wheels and cast-iron, malleable-iron, or steel pellets.

Blast cleaning shall be performed with SAE No. S-330 shot or smaller, SAE No. C-25 grit or smaller, or dry sand, garnet, or olivine passing through a 16 mesh sieve (1.18 mm), U.S. Standard Sieve Series.

The surface, if dry blasted, shall be brushed with clean brushes made of hair, bristle, or fiber, or blown off with compressed air (from which determental oil and water have been removed), or cleaned by vacuum, for the purpose of removing any traces of blast products from the surface, and also for the removal of abrasive from pockets and corners.

The surface, if wet sandblasted, shall be cleaned by rinsing with fresh water to which sufficient corrosion inhibitor has been added to prevent rusting, or with fresh water followed immediately by an inhibitive treatment. This cleaning shall be supplemented by brushing, if necessary, to remove any residue.

The compressed air used for nozzle blasting shall be free of detrimental amounts of water or oil. Adequate separators and traps shall be provided.

Blast cleaning operations shall be done in such a manner that no damage is done to partially or entirely completed portions of the work.

The blast cleaned surface shall be examined for any traces of oil, grease, or smudges deposited in the cleaning operations. If present, they shall be removed as outlined under “Method A”. Cleaned surfaces will be approved by the Engineer prior to painting.

1202.10.7 Schedule of Paint Coats for Metal

Steel structures shall be painted with not less than the number and thicknesses of coats of paint specified for the selected system. The color of each coat shall be sufficiently different from the preceding coat to allow easy verification of the coats applied. The color of the final coat shall be as specified in the Contract Documents or as approved by the Engineer.

1202.10.8 Painting Metal Surfaces

a. Time of Application – The prime coat of paint, or pretreatment when specified, shall be applied as soon as possible after the surface has been cleaned and before deterioration of the surface occurs. Any oil, grease, soil, dust, or foreign matter deposited on the surface after the surface preparation is completed shall be removed prior to painting. In the event that rusting occurs after completion of the surface preparation, the surface shall be again cleaned.

Particular care shall be taken to prevent the contamination of cleaned surfaces with salts, acids, alkali, or other corrosive chemicals before the prime coat is applied and between applications of the remaining

coats of paint. Such contaminants shall be removed from the surface. Under these circumstances, the pretreatments or, in the absence of a pretreatment, the prime coat of paint shall be applied immediately after the surface has been cleaned.

b. Storage of Paint and Thinner – All paint and thinner should be stored in a separate building or room that is well ventilated and free from excessive heat, sparks, flames or the direct rays of the sun.

All containers of paint should remain unopened until required for use. Containers which have been opened shall be used first.

Paint which has livered, gelled, or otherwise deteriorated during storage shall not be used. Thixotropic materials which may be stirred to attain normal consistency are satisfactory.

c. Mixing and Thinning – All ingredients in any container of paint shall be thoroughly mixed before use and shall be agitated often enough during application to keep the pigment in suspension.

Paint mixed in the original container shall not be transferred until all settled pigment is incorporated into the vehicle. This does not imply that part of the vehicle cannot be poured off temporarily to simplify the mixing.

Mixing shall be by mechanical methods, except that hand mixing will be permitted for containers up to 20 liters in size.

Mixing in open containers shall be done in a well ventilated area away from sparks or flames.

Paint shall not be mixed or kept in suspension by means of an air stream bubbling under the paint surface.

Where a skin has formed in the container, the skin shall be cut loose from the sides of the container, removed and discarded. If such skins are thick enough to have a practical effect on the composition and quality of the paint, the paint shall not be used.

The paint shall be mixed in a manner which will ensure breaking up of all lumps, complete dispersion of settled pigment, and a uniform composition. If mixing is done by hand, most of the vehicle shall be poured off into a clean container. The pigment in the paint shall be lifted from the bottom of the container with a broad, flat paddle, lumps shall be broken up, and the pigment thoroughly mixed with the vehicle. The poured-off vehicle shall be returned to the paint with simultaneous stirring, or pouring repeatedly from one container to another until the composition is uniform. The bottom of the container shall be inspected for unmixed pigment.

Tinting pastes or colors shall be wetted with a small amount of thinner, vehicle, or paint and thoroughly mixed. The thinned mixture shall then be added to the large container of paint and mixed until the color is uniform.

Paint which does not have a limited pot life, or does not deteriorate on standing, may be mixed at any time before using, but if settling has occurred it shall be remixed immediately before using. Paint shall not remain in spray pots, painters' buckets, etc., overnight, but shall be gathered into a container and remixed before use.

No thinner shall be added to the paint unless necessary for proper application. In the event of thinning being required, the type of thinner and amount added must be strictly in accordance with the manufacturer's recommendations.

All thinning shall be done under supervision of a competent person.

d. Application of Paint

i. General – The oldest of each kind of paint shall be used first. Paint shall be applied by brushing or spraying or a combination of these methods. Daubers or sheepskins may be used when no other

method is practicable for proper application in places of difficult access. Dipping, roller coating or flow coating shall be used only when specifically authorized.

Open seams at contact surfaces of built up members which would retain moisture should be caulked with red lead paste, or other approved material, before the second undercoat of paint is applied.

Paint shall only be applied when weather and atmospheric conditions are in accordance with the manufacturer's recommendations.

Any applied paint exposed to excess humidity, rain or condensation shall first be permitted to dry. The damaged areas of paint shall be removed, the surface again prepared and then repainted with the same number of coats of paint of the same kind as the undamaged areas.

If stripe painting is stipulated in these Specifications or if the Contractor chooses to do so at his option, all edges, corners, crevices, rivets, bolts, welds, and sharp edges shall be painted with the priming paint by brush before the steel receives its first full prime coat of paint. Such striping shall extend for at least 25 mm from the edge. When practicable, this stripe coat shall be permitted to dry before the prime coat is applied; otherwise, the stripe coat shall set to touch before the full prime coat is applied. However, the stripe coat shall not be permitted to dry for a period long enough to allow rusting of the unprimed steel. When desired, the stripe coat may be applied after a complete prime coat.

To the maximum extent practical, each coat of paint shall be applied as a continuous film of uniform thickness, free of pores. Any thin spots or areas missed in the application shall be repainted and permitted to dry before the next coat of paint is applied.

Maximum and minimum over coating times for paint systems shall be in accordance with the manufacturer's instructions.

ii. **Brush Application –** Paint shall be worked into all crevices and corners where possible and surfaces not accessible to brushes shall be painted by spray, daubers, or sheepskins. All runs or sags shall be brushed out. There shall be a minimum of brush marks left in the applied paint.

iii. **Spray Application of Paint –** The equipment used for spray application of paint shall be suitable for the intended purpose, shall be capable of properly atomizing the paint to be applied and shall be equipped with suitable pressure regulators and gauges. The air caps, nozzles, and needles shall be those recommended by the manufacturer of the equipment for the material being sprayed. The equipment shall be kept in satisfactory condition to permit proper paint application. In closed or recirculating paint spray systems, where gas under pressure is used over the liquid. The gas shall be inert, e.g. nitrogen.

Traps or separators shall be provided to remove oil and water from the compressed air. These traps or separators shall be of adequate size and shall be drained periodically during operations. The air from the spray gun impinging against the surface shall show no water or oil.

Paint ingredients shall be kept properly mixed in the spray pots or containers during paint application either by continuous mechanical agitation or by intermittent agitation as frequently as necessary.

The pressure on the material in the pot and of the air at the guns shall be adjusted for optimum spraying effectiveness. The pressure on the material in the pot shall be adjusted when necessary for changes in elevation of the gun above the pot. The atomizing air pressure at the gun shall be high enough to atomize the paint properly but not so high as to cause excessive fogging of paint, excessive evaporation of solvent, or loss by overspray.

Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film. Any solvents left in the equipment shall be completely removed before applying paint to the surface being painted.

Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray pattern shall be adjusted so that the paint is deposited uniformly. During application, the gun shall be held perpendicular as to the surface and at a distance which will ensure that a wet layer of paint is deposited on the surface. The trigger of the gun shall be released at the end of each stroke.

All runs and sags shall be brushed out immediately or the paint shall be removed and the surface repainted. Spray application of prime coats shall in all cases be immediately followed by brushing.

Areas inaccessible to the spray gun shall be painted by brush. If not accessible by brush, small rollers may be used. Brushes shall be used to work paint into cracks, crevices, and blind spots which are not adequately painted by spray.

iv. Shop Painting – Shop Painting shall be done after fabrication and before any damage to the surface occurs from weather or other exposure. The type and thickness of the shop coat shall be as recommended by the paint manufacturer. Contact surfaces which are specified to be unpainted shall be adequately protected from rust, overspray, and any other contamination until joints are made.

Unless otherwise specified, surfaces to be in contact only after field erection shall be fully painted except where shown on the Drawings.

Surfaces not to be in contact but which will be inaccessible after assembly shall receive the full paint coats specified.

For coated faying surfaces of friction-grip connections, the Contractor shall supply certification that the coating proposed for use has been tested by an independent laboratory and meets the slip coefficient requirements used in the design of the connection for the thickness to be applied. Testing shall be in accordance with 'Appendix A of the Specification for Structural Joints Using ASTM A325 or ASTM A490 Bolts' of the Research Council on Structural Connections. (American Institute of Steel Construction).

The paint shall be applied strictly in accordance with the manufacturer's recommendations, particularly regarding thickness of application, and allowed to cure for the required time before the joints are made.

Unless shown otherwise on the Drawings, areas of steel surface to be in contact with concrete shall not be painted. Unless otherwise shown on the Drawings, the areas of steel surfaces to be in contact with wood shall receive either the full paint coats specified or the three shop coats of the specified primer.

If the paint would be harmful to a welding operator or would be detrimental to the welding operation or the finished welds, the steel shall not be painted within a suitable distance from the edges to be welded until after completion of the welding and slag removal.

Antiweld spatter coatings shall be removed before painting. Weld slag and flux shall be removed by methods at least as effective as those specified for the cleaning.

Machine-finished or similar surfaces that are not to be painted, and do not require permanent protection, shall be protected with a coating of rust inhibitive petroleum, or other coatings which may be more suitable for special conditions.

Erection marks and weight marks shall be copied on areas that have been previously painted with the shop coat.

v. Field Painting – Steel structures shall be painted as soon as practicable after erection. Each field coat of paint shall have a minimum dry film thickness as specified by the manufacturer for the particular system used and the specified 'Time to First Maintenance'. Where measurement of the dry film thickness may become difficult or dangerous unless the Contractor maintains or provides suitable means of access, wet film measurement may be authorized. In such cases the Engineer will

pre-determine and notify the Contractor of the required wet film thickness, for each type of paint, to comply with the minimum dry film thickness specified.

Metal which has been shop coated shall be touched up with the same type of paint as the shop coat. This touch up shall include cleaning and painting of field connections, welds, rivets, and all damaged or defective paint and rusted areas. The Contractor may at his option apply an overall coat of shop coat in place of touch up or spot painting.

Surfaces (other than contact surfaces) which are accessible before erection but which will not be accessible after erection shall receive all field coats of paint before erection.

If possible, the final coat of paint shall not be applied until all concrete work is finished. If concreting or other operations damage any paint, the surface shall be cleaned and repainted. All cement or concrete spatter and drippings shall be removed before any paint is applied.

Wet paint shall be protected against damage from dust or other detrimental foreign matter to the extent practicable.

vi. Drying of Painted Metal –Drying and over coating times shall be as per the manufacture's recommendations for the particular atmospheric conditions prevailing at the time of painting. No painted metal shall be subjected to immersion before the paint is dried through. Paint shall be protected from rain, condensation, and contamination, until dry, to the fullest extent practicable.

vii. Handling of Painted Steel – Painted steel shall not be handled until the paint has dried, except for necessary handling in turning for painting or stacking for drying.

Paint which is damaged in handling shall be scraped off and touched up with the same number of coats and kinds of paint as were previously applied to the steel.

Painted steel shall not be loaded for shipment or shipped until it is dry.

Precautions shall be taken to minimize damage to paint films resulting from stacking members.

1202.10.9 Health and Safety

The Contractor shall make himself aware of the health and safety implications of all products and processes used in the cleaning and painting of steelwork, including where necessary working at heights and working in confined spaces. He shall provide all necessary safe means of work and inspection including, but not limited to, safe means of access/egress, ventilation, all necessary personal protective equipment (including but not limited to, filter masks, respirators and air-fed helmets, fall arrest equipment etc.), and shielding for the protection of the Public.

1202.11 ERECTION

a. The Contractor shall erect all metal work to conform to the lines and elevations as shown on the approved shop drawings and as directed by the Engineer. The Contractor shall provide the false work and all tools machinery and appliances necessary for the expeditious handling of the work.

b. Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and stored. Long members, such as columns and trusses, shall be supported on skids placed near enough together to prevent damage from deflection

c. The false work shall be properly designed and substantially constructed and maintained for the loads which will come upon it. The Contractor, if required, shall prepare and submit to the Engineer for approval plans for false work or for changes in an existing structure necessary for maintaining traffic. Approval of the Contractor's plans shall not relieve the Contractor of his responsibility under the Contract.

d. Before starting the work of erection, the Contractor shall inform the Engineer fully as to the method of erection he proposes to follow, and the amount and character of equipment he proposes to use, all of which shall be subject to the approval of the Engineer. The approval of the Engineer shall not relieve the Contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the Drawings and Specifications. No work shall be done until such approval by the Engineer has been obtained.

e. The parts shall be accurately assembled as shown on the shop drawings and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the Cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully bolted and all other truss connections pinned and bolted. Bolts in splices of butt joints of compression members and bolts in railings shall not be installed until the span has been swung.

f. The correction of minor misfits involving minor amounts of reaming or cutting will be considered a legitimate part of the erecting. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming or slight cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The correction shall be made in the presence of a representative of the Engineer. The Contractor shall be responsible for all misfits, errors and damage and shall make the necessary corrections and replacement at his own expense.

g. Upon completion of the erection and before final acceptance the Contractor shall remove all false work, excavated or useless materials, rubbish, replace or renew any fences damaged, and restore in an acceptable manner all property, both public and private, which may have been damaged during the execution of this work, and shall leave the site and adjacent highway in a neat and presentable condition satisfactory to the Engineer.

h. Erection work as specified herein or as directed by the Engineer shall not be paid for separately but shall be considered as incidental to the work of furnishing and installing steel components and structures and payment shall be included in the items of work shown in the Bills of Quantities.

1202.12 SOURCE QUALITY CONTROL

1202.12.1 Shop Quality Control

A. Contractor will engage an independent testing and inspecting agency to perform shop inspections and tests and to prepare test reports, subject to the Engineer’s approval, on Contractor’s expense.

1. Testing agency will conduct and interpret tests and state in each report whether test specimens comply with or deviate from requirements.
2. Provide testing agency with access to places where structural steel work is being fabricated or produced so required inspection and testing can be accomplished.

B. Correct deficiencies in or remove and replace structural steel that inspections and test reports indicate do not comply with specified requirements.

C. Additional testing, at Contractor's expense, will be performed to determine compliance of corrected work with specified requirements.

D. Shop-bolted connections will be tested and inspected according to American Institute of Steel Construction (AISC) specifications and Research Council on Structural Corrosion (RCSC's) "Specification for Structural Joints Using ASTM A 490 Bolts."

1. Direct-tension indicator gaps will be verified to comply with ASTM F 959, Table 2.

E. Testing agency may inspect structural steel at plant before shipment; however, the Engineer reserves the right, at any time before final acceptance, to reject material not complying with specified requirements. .

F. Shop Welding: Inspect and test during fabrication of structural steel assemblies, as follows:

1. Certify welders and conduct inspections and tests as required. Record types and locations of defects found in work. Record work required and performed to correct deficiencies.
2. Perform visual inspection of all welds.
3. Perform non destructive tests of welds on 10% of all fillet weld lengths as a first testing round, depending on its results, the Engineer might instruct the Contractor to extend the testing process and/or to replace welder at no extra cost. Selection of tested samples to be approved by the Engineer. Non-destructive tests of butt welds to be done on 100% of the welded lengths.

3.1 Fillet Welds
- Liquid Penetrant Inspection: ASTM E 165, or,
- Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld of fillet welds at random. Cracks or zones of incomplete fusion or penetration not acceptable.

3.2 Butt Welds
- Radiographic Inspection: ASTM E 94 and ASTM E 142; minimum quality level "2-2T", or,
- Ultrasonic Inspection: ASTM E 164 for 100% of full penetration and partial welds.

G. In addition to visual inspection, shop-welded shear connectors will be inspected and tested according to requirements of AWS D1.1 for stud welding and as follows:

1. Bend tests will be performed when visual inspections reveal either less than a continuous 360-degree flash or welding repairs to any shear connector.

2. Tests will be conducted on additional shear connectors when weld fracture occurs on shear connectors already tested, according to requirements of AWS D1.1.

1202.12.2 Field Quality Control

A. On the Contractor’s expenses, the Employer will engage an independent testing and inspecting agency to perform field inspections and tests and to prepare test reports.

1. Testing agency will conduct and interpret tests and state in each report whether tested work complies with or deviates from requirements.

B. Correct deficiencies in or remove and replace structural steel that inspections and test reports indicate do not comply with specified requirements.

C. Additional testing, at Contractor's expense, will be performed to determine compliance of corrected work with specified requirements.

D. Field-bolted connections will be tested and inspected according to RCSC's "Specification for Structural Joints Using ASTM A 490 Bolts."

1. Direct-tension indicator gaps will be verified to comply with ASTM F 959, Table 2.

E. Field Welding: Inspect and test during erection of structural steel as follows:

1. Certify welders and conduct inspections and tests as required. Record types and locations of defects found in work. Record work required and performed to correct deficiencies.

2. Perform visual inspection of all welds.

3. Perform non destructive tests of welds on 10% of all fillet weld lengths as a first testing round, depending on its results, the Engineer might instruct the Contractor to extend the testing process and/or to replace welder at no extra cost. Selection of tested samples to be approved by the Engineer. Non-destructive tests of butt welds to be done on 100% of the welded lengths.

   3.1 Fillet Welds
   - Liquid Penetrant Inspection: ASTM E 165, or,
   - Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld of fillet welds at random. Cracks or zones of incomplete fusion or penetration not acceptable.

   3.2 Butt Welds
   - Radiographic Inspection: ASTM E 94 and ASTM E 142; minimum quality level "2-2T", or,
   - Ultrasonic Inspection: ASTM E 164 for 100% of full penetration and partial welds.

F. Weld defects: cracks, overlaps, lack of penetration or incomplete fusion shall not be allowed.

G. Lamination tests: carry out ultrasonic testing for lamination on all head plates for moment connections (15 mm thick or above) in accordance with DIN 54120 or ASTM E164.

H. Non-shrink grout: prepare 50 mm cubes and test for compressive strength in accordance with ASTM C109.

I. In addition to visual inspection, field-welded shear connectors will be inspected and tested according to requirements of AWS D1.1 for stud welding and as follows:

   1. Bend tests will be performed when visual inspections reveal either less than a continuous 360-degree flash or welding repairs to any shear connector.

   2. Tests will be conducted on additional shear connectors when weld fracture occurs on shear connectors already tested, according to requirements of AWS D1.1..

J. Tolerances: The permissible deviation of fabricated and erected structures is to be in accordance with the limitations of the AISC.

K. Equipment: provide necessary facilities and equipment for specified tests in the fabrication shop and on site. Calibrate load measuring equipment at regular intervals agreed with Engineer.

M. Results: submit three copies of test and examination results to Engineer immediately they are available.

1202.13 MEASUREMENT AND PAYMENT

1202.13.1 Method of Measurement and Basis of Payment

The furnishing, fabrication, and erection of structural steel shall be measured by weight in tones (t.). The weight includes all components and fittings. The weight is measured from the overall lengths of components and fittings with no deductions for splay cuts or mitred ends or for the weight of metal removed to form notches and hole each less than 0.10 m2 in area measured in the plane. No allowance is made for the weight of weld fillets, bolts, nuts, washers, rivets, protective coatings and fire proofing. The weight of steel is taken for measurement as 7.85 t/m3. Payment shall be made at rates inserted in the Bills of Quantities and such rates shall include all labour, materials, fabrication and erection, connection fittings either welded or bolted, anchor bolts and other fixing devices, temporary bracing, protective coatings (painting) and grouting under anchorage.

1202.13.2 Item in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1202.1	Furnishing, Fabrication and Erection of Structural Steel	t.

1203 - FENCING

1203.01 DESCRIPTION

The Contractor shall construct all resin clad chain link fencing complete with hardware and appurtenances as shown on the Drawings, in accordance with these Specifications and in conformity with the lines and grades directed by the Engineer.

1203.02 MATERIALS

Unless otherwise shown in the Contract Documents, all materials to be furnished and installed shall conform to all requirements of AASHTO M181 and as specified herein. Where there is a conflict between these Specifications and AASHTO M181, the requirements of these Specifications shall govern.

1203.02.1 Posts and Braces

a. The base metal for the manufacture of posts and braces shall conform to the requirements of AASHTO M181, except that the carbon content of steel posts shall not be more than 0.4%. Steel made by the oxygen furnace process will be acceptable. Posts and braces shall be galvanized and sampling of pipe posts for performing galvanizing tests shall conform to the requirements of ASTM A53M.

b. Fence posts and braces and gate frames shall conform to the following requirements unless otherwise shown on the Drawings.

Location	Type	Minimum O.D. (mm)	Minimum Wt Per Linear Meter in kg
End, corner and pull, posts	Pipe	60.3	5.43
Line Posts	Pipe	48.3	4.05
Braces	Pipe	42.2	3.38

Table 1203.02.1 – Post and Brace Requirements

c. Posts on each side of gates shall be pipe conforming to the following requirements.

Gate Opening (m)	Minimum O.D. (mm)	Minimum Wt Per Linear Meter in kg
1.5	60.3	5.43
4.0	73.0	8.62

Table 1203.02.2 – Gate Post Requirements

d. All fence and gate posts (including all end and corner posts) shall be fitted with plastic or vinyl coated Aluminum or tops designed to fit securely over the posts and crowned to shed water.

e. Changes in line where the angle of deflection is 15 degrees or more shall be considered as corners and corner posts shall be installed.

f. Extension arms, stretcher bars, and other required fittings and hardware shall be steel, malleable iron or wrought iron and shall be hot dipped galvanized. All required fittings and hardware shall be fastened to the posts in a manner approved by the Engineer.

1203.02.2 Fabric

Chain link fence fabric shall be galvanized steel fabric conforming to the specifications of AASHTO M181.

The base metal for the fabric shall be commercial quality, medium high carbon hot-dip galvanized steel wire. All chain link fence fabric shall be woven into approximately 50 mm mesh such that in a vertical dimension of 600 mm along the diagonals of openings there shall be at least 7 meshes.

1203.02.3 Miscellaneous

a. Between posts, chain link fabric shall be fastened to a top and bottom tension cable. The tension cable shall be 10 gauge galvanized steel of good commercial quality.

b. Tie wires and post clips shall be at least 9 gauge galvanized steel.

c. Turnbuckles and truss tighteners shall be fabricated of commercial quality steel, malleable iron, or wrought iron and shall be hot dipped galvanized. The truss tighteners shall have a strap thickness of not less than 6 mm.

d. Class K180 sulphate resisting Portland Cement concrete for post footings shall comply with the requirements of Section 5 (Concrete Works) of these Specifications.

1203.02.4 Gates

a. Gate frames shall be constructed of not less than 42.2 mm galvanized pipe weighing 3.38 kg/m and conforming to the specifications of ASTM A53M. Gate frames shall be cross trussed with 9 mm adjustable truss rods. The corners of gate frames shall be fastened together and reinforced with a malleable iron fitting designed for the purpose or by welding. Welding shall be to the approval of the Engineer and all welds shall be ground smooth.

b. Chain link fence fabric specified for the fence shall be attached to the gate frame by the use of stretcher bars and the tie wires as specified for fence construction, and suitable tension connectors shall be spaced at approximately 300 mm intervals.

c. The gates shall be hung by at least two steel or malleable iron hinges not less than 80 mm in width, so designed as to securely clamp to the gate post and permit the gate to be swung back against the fence. The bottom hinge shall have a socket to take the ball end of the gate frame.

d. Gates shall be provided with a combination steel or malleable iron catch and locking attachment of approved design. Stops to hold gates open and a center rest with catch shall be provided where required.

e. All gates shall be provided with standard hardware and heavy duty padlocks. All padlocks shall conform to Federal Specification FF-P-101E and shall be master- keyed. Padlocks shall be 50.8 mm Type EPC, 5 pin tumbler mechanism, brass or bronze, solid case, with chain and as required by the Engineer.

1203.02.5 Finishes

a. **Posts, Gate Frames, Rails etc. -** All posts, gate frames, rails and similar materials shall have a coating thickness of 254 to 356 micron of a Polyvinyl Chloride (PVC) which has been chemically bonded to the metal surface with an appropriately cured primer. Final finish color shall be as shown on the Drawings or as directed by the Engineer.

b. **Fabric**

i. 6 gauge finished thickness resin clad fabric shall include a vinyl-coating minimum wall thickness of 0.559 mm over the galvanized substrate.

ii. The vinyl-coating shall be continuously extruded (not sprayed or dipped) over the galvanized steel wire by the thermal extrusion process under pressures to 352 kg/cm2 to insure a dense and impervious covering free of voids, having a smooth and lustrous surface appearance.

iii. The wire shall be vinyl-clad before weaving and shall be free and flexible at all joints.

iv. Plasticized Polyvinyl Chloride (PVC) with low temperature (-20^{o}C) plasticizer, no fillers, extenders or extraneous matter, other than the necessary stabilizers and pigments shall be used. Colors will be stabilized and have a light fastness that shall withstand a minimum WEATHER-0-METER exposure of 4,000 hours without any deterioration (Test Equipment Operating Light and Water Exposure Apparatus Carbon-Arc Type) ASTM D1499, E 42, Type E.

v. Alternatively a sample of fencing may be subject to 2,000 hours exposure at 85^{o}C humidity in a humidity oven. The sample shall exhibit no color loss, cracking, peeling, blistering or other deterioration.

vi. The vinyl-clad wire shall withstand an accelerated ageing test of 2,000 hours at 62^{o}C without cracking or peeling. The vinyl-clad wire shall be of a self extinguishing character and be insulated for 12,000 volts and a typical tensile strength for the vinyl coating shall be 190 kg/cm2 elongation 275%, having a specific gravity of 1.30 maximum. Hardness not less than durometer A90, plus or minus 5. High abrasion resistance, maximum deformation of 15% at 120^{o}C, (UL Test) under 500 gram load and compression cut through of 105.5 kg/cm2 (Bell Laboratory Test).

vii. The vinyl covering shall, in addition, resist attack from prolonged exposure to dilute solutions of most common mineral acids, sea water and dilute solutions of most salts and alkali.

c. **Pipe Resin –** The pipe resin shall have a Specific Gravity of 1.32 Max.; a Tensile Strength of 105.5 kg/cm^{2} ; a Minimum Elongation of 200%; a Tear Strength of 15 mil – 0.361b. per mil; Hardness of Coating of 80 $\pm$5 Shore A Durometer; a Dielectric Strength of 40 Volts per micron ; a Volume Resistivity of 2.0 x 10" ohm/mm; a Brittle Temperature of -20^{o}C (Film), and a Water Absorption at 25^{o}C for one week of 0.70% maximum, and at 94^{o}C for two hours of 0.95% maximum.

d. **Pipe Resin Test Criteria –** The resin formulation shall meet the standard ASTM E42-64 (D) minimum 5,000 hour WEATHER-O-METER requirement without cracking, blistering, or loss of adhesion. The protective resin coating shall withstand an impact resistance test (Gardner Test Method) of a minimum of 1850 mm/kg . Certified abrasion resistance shall be in excess of a ten minute blast of 5.6 kg/cm^{2} at 305 mm at 25^{o}C with S230 shot at an impingement angle of 90 without exposing the steel substratum. It shall not support combustion and shall be self-extinguishing; and shall withstand a salt spray test (ASTM B117) of greater than 10,000 hours, with no perceptive deterioration to coating or evidence of metal corrosion for unscored samples. For scored samples after exposure of 1,000 hours, under-cutting shall not exceed 5 mm. The protective resin coating shall exhibit a chemical resistance after prolonged exposure at 24^{o}C to fumes and shall, in addition, resist attack from prolonged exposure to dilute solutions of most common mineral acids, sea water and dilute solutions of most salts and alkalis.

1203.03 CONSTRUCTION

Line posts shall be spaced at not more than 3 meter intervals, measured from center to center of posts. In general, in determining the post spacing, measurement will be made parallel to the slope of the natural ground, and all posts shall be placed in a vertical position, except in unusual locations where the posts shall be set perpendicular to the ground surface if so directed by the Engineer.

All posts shall be set in concrete footings conforming to the details shown on the Drawings.

End, corner, pull and gate posts shall be braced to the nearest line post with galvanized diagonal or horizontal braces used as compression members and galvanized 9 mm steel truss rods with turnbuckles or truss tighteners used as tension members. Pull posts shall be placed at locations agreed by the Engineer. They shall be placed at 200 meter intervals between posts to which the ends of the fabric are clamped or midway between such posts when the distance is greater than 40 meters but less than 200 meters.

Excavation or filling along a fence line where required shall be in accordance with Section 2 (Earthworks) of these Specifications.

Chain link fabric shall be fastened on the side of the posts designated by the Engineer.

The fabric shall be stretched and securely fastened to the posts, and between posts the top and bottom edges of the fabric shall be fastened to the tension wires. Tension wires shall be stretched tight. The bottom tension wire shall be installed on a straight grade between posts by excavating the high points of ground and in no case will filling of depressions be permitted.

The fabric shall be fastened to end, corner and gate posts with minimum 10 mm diameter steel stretcher bars and not less than 3 mm by 18 mm stretcher bar bands spaced at maximum 300 mm intervals. The fabric shall be fastened to line posts and tension wires with tie wires or post clips. The fasteners shall be spaced at maximum intervals of 500 mm.

Surplus excavated material remaining after the fence has been constructed shall be disposed of in a uniform manner as directed by the Engineer.

1203.04 MEASUREMENT AND PAYMENT FOR FENCING

1203.04.1 Method of Measurement and Basis of Payment

Chain link fencing shall be measured by the linear meter (m) in place and accepted. The length paid for shall be the overall length, parallel to the ground surface, from center to center of end posts but excluding gates.

Payment for chain link fencing shall be at the rate included in the Bills of Quantities, which price shall be full compensation for all labour, materials and equipment, and for doing all work necessary for the construction including all excavation, backfilling and grading required, drilling post holes, furnishing and placing concrete backfill, setting posts, braces, tension wires, furnishing and installing all fencing materials, and all hardware and fittings, and all other work incidental to and in connection with the construction of the completed fences. No other compensation will be allowed.

1203.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1203.4.1	Chain link fencing	m

1203.05 MEASUREMENT AND PAYMENT FOR GATES

1203.05.1 Method of Measurement and Basis of Payment

Gates shall be measured by the number of single leaf and by the number of double leaf units.

Payment for gates in chain link fencing shall be at the rates included in the Bills of Quantities, which rate shall be full compensation for all labour, materials and equipment for each size of gate, complete in place, including all materials, hardware and appurtenances and all other work incidental to and in connection with the construction of complete gates.

1203.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1203.5.1	Single Leaf Gates	nr
1203.5.2	Double Leaf Gates	nr

1204 - METAL BEAM GUARD RAIL

1204.01 DESCRIPTION

The Contractor shall construct all guard rails complete with posts, breakaway cable terminal sections, foundations, end sections etc., all as shown on the Drawings and in accordance with the lines and grades as directed by the Engineer. The Contractor shall submit to the Engineer for his review and approval shop drawings complete with all details of the type of corrugated steel beam guard rail and fittings he proposes to use on this Project.

1204.02 MATERIALS AND CONSTRUCTION

a. At locations where public traffic is adjacent to metal beam guard railing work, all materials required to complete the guard railing construction at any one location shall be available before beginning the guard railing work at that location.

b. Welding shall conform to the requirements in AWS D1.1. Welds on exposed surfaces shall be ground flush with the adjacent surfaces.

c. All completed steel components and hardware for railings shall be galvanized in conformance with the requirements in AASHTO Designation: M 180 and Clause 1201.05 (Galvanizing) of these Specifications.

d. After galvanizing, all elements of the railing shall be free of fins, abrasions, rough or sharp edges and other surface defects and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by the Engineer. Kinks, twists or bends in railing elements may be cause for rejection of the railing elements.

e. Abraded or damaged galvanized surfaces of steel railing and posts, and ends of steel railing cut after galvanizing, shall be cleaned and regalvanized as specified for galvanizing, except if permitted by the Engineer, repairs to the surfaces may be made in conformance with the provisions in Clause 1201.05 (Galvanizing) of these Specifications.

f. Mortar shall conform to the provisions in Section 5 (Concrete Works) of these Specifications and shall consist of one part Portland cement and 3 parts sand.

g. Mortar shall be cured by either the water method or the curing compound method using curing compound as provided in Clause 504.06 (Curing) of Section 5 (Concrete Works) of these Specifications.

h. Steel posts shall be either W200 x 15 or W150 x 14 as shown on the Drawings and shall be galvanized as specified herein. Sections shall conform to AASHTO M160M.

i. The rail elements, backup plates, terminal sections, end and return caps, bolts, nuts and other fittings shall conform to the requirements in AASHTO Designation: M 180, except bolt hole spacing shall be 2000 mm center to center or as otherwise shown on the Drawings. The rail elements, backup plates, terminal sections, end and return caps shall conform to Class A, Type 1 W-Beam guard railing as shown in AASHTO Designation: M 180. The edges and center of the rail element shall contact each post block. Rail element joints shall be lapped not less than 320 mm and bolted. The rail metal, in addition to conforming to the requirements in AASHTO Designation: M 180, shall withstand a cold bend, without cracking, of 180 degrees around a mandrel of a diameter equal to 2.5 times the thickness of the plate.

j. Workmanship shall be equivalent to good commercial practice and all edges, bolt holes and surfaces shall be free of torn metal, burrs, sharp edges and protrusions.

k. Two certified copies of mill test reports from which the rail element is formed shall be furnished to the Engineer.

l. Bolts shall have shoulders of such shape that will prevent the bolts from turning. Holes in rail elements shall be of similar shape as the bolt shoulder.

m. The rail elements at joints shall have full bearing. When the radius of curvature is 45 m or less, the rail elements shall be shaped in the shop. The radius of curvature shall be stenciled on the back of each section of rail elements in numerals 65 mm in height.

n. Steel posts shall be fabricated from steel conforming to the requirements in ASTM Designation: A 36/A 36M, unless otherwise specified. Two certified copies of mill test reports of each heat of steel from which steel posts are formed or fabricated shall be furnished to the Engineer.

o. Steel posts shall be driven. If ground conditions are such that pilot holes are necessary to prevent damage to posts during driving, any space around steel posts after driving shall be filled with dry sand or pea gravel.

p. At the Contractor's option, steel foundation tubes with sole plates attached, shall be either driven, with or without pilot holes, or placed in drilled holes. Any space around the steel foundation tubes shall be backfilled with selected earth, free of rock, placed in layers approximately 100 mm thick and each layer shall be moistened and thoroughly compacted.

q. Posts shall be placed at equal intervals, as shown on the Drawings, except that the end posts may be spaced closer to adjacent posts if directed by the Engineer.

r. The bolted connection of the rail element to the post shall withstand a 22 KN pull at right angles to the line of the railing.

s. All metal work shall be fabricated in the shop, and no punching, cutting or welding will be permitted in the field. Rail elements shall be lapped so that the exposed ends will not face approaching traffic.

t. Terminal sections shall be installed in conformance with the manufacturer's recommendations.

u. Components built up from structural steel plates welded together may be substituted for the rolled steel components shown on the Drawings provided that the depth, width and average thicknesses are at least equal to those of the rolled section; and further provided that, for the welded section, the steel plates conform to the requirements in ASTM Designation: A 36/A 36M, and the flanges are welded to the web with continuous fillet welds on each side of the web.

v. Metal beam guard railing shall be connected to bridge railings, barriers, retaining walls, abutments and other flat concrete surfaces in conformance with the details shown on the Drawings and the following provisions:

Metal rail posts, box spacers and plate washers shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M.

The metal box spacer shall be either fabricated from separate plates and welded or press-formed and welded.

High strength bolts shall conform to the requirements in ASTM Designations: A 325, A 325M or A 449, or the bolts may be fabricated from steel rod conforming to the requirements in ASTM Designation: A 449. The bolts or rods shall conform to the mechanical requirements in ASTM Designation: A 325 or A 325M after galvanizing. Nuts and washers shall conform to the requirements in ASTM Designation: A 325 or A 325M.

For the connection of guard railing to new bridge railing or barriers, anchor bolt holes shall be formed in the concrete parapet by the use of metal sleeves.

For the connection of guard railing to existing bridge railing or barriers, anchor bolt holes shall be drilled in the concrete parapet as shown on the Drawings. Areas around the holes spalled or otherwise damaged during drilling, as determined by the Engineer, shall be repaired with a mixture of commercial quality epoxy adhesive and sand. The proportions of epoxy adhesive to sand shall be from 1:4 to 1:6, the exact proportion to be determined by the Engineer. The cementing agent shall consist of a 2-component epoxy adhesive manufactured especially for the making of epoxy-sand mortar. The 2 components and the epoxy-sand mixture shall be mixed in conformance with the manufacturer's instructions.

Footings for railing posts shall be constructed of k180 concrete conforming to the provisions in Section 5 (Concrete Works) of these Specifications. Reinforcement shall conform to the provisions in Section 504.02 (Steel For Reinforced Concrete).

Concrete shall be placed against undisturbed material of the excavated holes for footings.

w. End anchor assemblies and rail tensioning assemblies for metal beam guard railing shall be constructed as shown on the Drawings and shall conform to the following provisions:

An end anchor assembly for metal beam guard railing shall consist of an anchor cable, an anchor plate, a single anchor rod or double anchor rods, hardware and one concrete anchor.

A rail tensioning assembly for metal beam guard railing shall consist of an anchor cable, an anchor plate, and hardware.

The anchor plate, metal plates, steel foundation tubes and steel sole plate shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M.

The anchor rods shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M, A 441 or A 572, or ASTM Designation: A 576, Grades 1018, 1019, 1021 or 1026. The eyes shall be hot forged or formed with full penetration welds. After fabrication, anchor rods with eyes that have been formed with any part of the eye below 870° C during the forming operation or with eyes that have been closed by welding shall be thermally stress relieved prior to galvanizing. The completed anchor rod, after galvanizing, shall develop a strength of 222 KN.

In lieu of built-up fabrication of anchor plates as shown on the Drawings, anchor plates may be press-formed from steel plate, with or without welded seams.

All bolts and nuts shall conform to the requirements in ASTM Designation: A 307, unless otherwise specified in the special provisions or shown on the Drawings.

Anchor cable shall be 19 mm performed, wire strand core or independent wire rope core (IWRC), galvanized in conformance with the requirements in Federal Specification RR-W-410F, right regular lay, manufactured of improved plow steel with a minimum breaking strength of 10.5 Tons. Two certified copies of mill test reports of each manufactured length of cable used shall be furnished to the Engineer. The overall length of each cable anchor assembly shall be as shown on the Drawings, but shall be a minimum of 1980 mm.

Where shown on the Drawings, cable clips and a cable thimble shall be used to attach cable to the anchor rod. Thimbles shall be commercial quality, galvanized steel. Cable clips shall be commercial quality drop forged galvanized steel.

The swaged fitting shall be machined from hot-rolled bars of steel conforming to AISI Designation: C 1035, and shall be annealed suitable for cold swaging. The swaged fitting shall be galvanized before swaging. A lock pin hole to accommodate a 6.4 mm, plated, spring steel pin shall be drilled through the head of the swage fitting to retain the stud in proper position. The manufacturer's identifying mark shall be stamped on the body of the swage fitting.

The 25 mm nominal diameter stud shall conform to the requirements in ASTM Designation: A 449 after galvanizing. Prior to galvanizing, a 9.5 mm slot for the locking pin shall be milled in the stud end.

The swaged fittings, stud and nut assembly shall develop the specified breaking strength of the cable.

The cable assemblies shall be shipped as a complete unit including stud and nut.

Clevises shall be drop forged galvanized steel and shall develop the specified breaking strength of the cable.

One sample of cable properly fitted with swaged fitting and right hand thread stud at both ends as specified above, including a clevis when shown on the Drawings, 990 mm in total length, shall be furnished to the Engineer for testing.

The portion of the anchor rod to be buried in earth shall be coated with a minimum 0.5 mm thickness of coal tar enamel conforming to AWWA Standard: C203 or a coal tar epoxy conforming to the requirements in Steel Structures Painting Council Paint Specification No. 16, Coal-Tar Epoxy-Polymide Black Paint or Corps of Engineers Specification, Formula C-200a, Coal-Tar Epoxy Paint.

Metal components of the anchor assembly shall be fabricated in conformance with good shop practice and shall be hot-dip galvanized in conformance with the provisions in Clause 1201.05 (Galvanizing) of these Specifications.

Anchor cables shall be tightened after the concrete anchor has cured for at least 5 days.

Concrete used to construct anchors for end anchor assemblies shall be K180 concrete conforming to the provisions in Section 5, (Concrete Works) of these Specifications.

Concrete shall be placed against undisturbed material of the excavated holes for end anchors. The top 305 mm of holes shall be formed, if required by the Engineer.

Reinforcing steel in concrete anchors for end anchor assemblies shall conform to the provisions in Clause 504.02 (Steel for Reinforced Concrete) of Section 5, (Concrete Works) of these Specifications.

x. Anchor bolts shown on the plans to be set with epoxy shall be placed in holes filled with the epoxy mixture specified in Clause 504.04 (Joints in Concrete Work) of Section 5, (Concrete Works) of these Specifications.

y. Surplus excavated material remaining after the guard railing has been constructed shall be disposed of as directed by the Engineer.

z. Railing parts furnished under these specifications shall be interchangeable with similar parts regardless of source.

1204.03 MEASUREMENT AND PAYMENT FOR METAL BEAM GUARD RAIL

1204.03.1 Method of Measurement and Basis of Payment

a. Breakaway cable terminal sections, both single and double sided shall be measured by the number.

b. Breakaway cable anchor assemblies at the trailing end of guard rail installations shall be measured by the number.

c. The remaining metal beam guard rail installation shall be measured by the meter run from center to center of supports, measured along the line and grade of the guardrail.

Payment for breakaway cable terminal sections, breakaway cable anchor assemblies and metal beam guard rail installation shall be at the rates entered in the Bills of Quantities which rates shall be full compensation for all labor, materials and equipment, for the construction and installation of the guard rail including posts, anchors, end sections, reinforced concrete foundations, fittings and fasteners, galvanizing and painting, and for all incidental accessories to complete the installations as shown on the Drawings or specified herein.

1204.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1204.1	Breakaway cable terminal section	nr
1204.2	Breakaway cable anchor assemblies	nr
1204.3	Metal beam guard rail	m

1205 - RAILING

1205.01 DESCRIPTION

The Contractor shall construct all railings complete with rails, posts, holding-down bolts and rail joints as shown on the Drawings and in accordance with these Specifications.

1205.02 MATERIALS

1205.02.1 Materials for Steel Railing

Materials for steel railings shall comply with the appropriate requirements of Clause 1201 of these Specifications.

1205.02.2 Materials for Aluminum Railing

a. Cast Aluminum railing posts shall conform to the requirements of AASHTO M193M and ASTM B108, alloy S7A – T4 (A444 – T4).

b. Aluminum alloy extruded rail shall conform to the requirements of ASTM B221 alloy, 6061-T6 or 6351-T5 with a minimum yield strength of 2466 kg/cm^2 , a minimum tensile strength of 2677 kg/cm^2 and as elongation of 10% in 50 mm.

c. Stainless steel hardware for Aluminum railings shall be machine bolts or cap screws conforming to ASTM A193M, grade B8, Class 2. Material for stainless steel flat washers and lock washers shall conform to the requirements of ASTM A240, Type 302.

d. Bearing pads shall conform to the requirements of Section 13 (Bearings and Expansion and Fixed Joints) of these Specifications.

1205.03 CONSTRUCTION

1205.03.1 General

Railings shall be constructed to the line and grade shown on the Drawings and shall not reflect any unevenness in the founding construction. Unless otherwise specified, all railing posts shall be vertical. For bridges railing shall not be placed on a space until centering or false work has been removed, rendering the space self-supporting. The Contractor shall co-ordinate and space the rail posts to miss light poles which are to be furnished and installed under the Contract.

1205.03.2 Construction of Steel Railings

The fabrication and erection of steel railings shall be in accordance with the appropriate requirements of Clause 1202 of these Specifications.

1205.03.3 Construction of Aluminum Railing

The fabrication and erection of Aluminum railings shall conform to the requirements of Clauses 1202.01 to 1202.08 inclusive and Clause 1202.11 of these Specifications subject to the following amendments and additions:

a. **Cutting** – Material 12.7 mm thick or less may be cut by shearing, sawing or milling. Material over 12.7 mm thick shall be sawed or milled.

   Cut edges shall be true and smooth and free from burrs or ragged breaks. Reentrant cuts shall be filleted by drilling prior to cutting.

   Flame cutting will not be permitted.

b. **Bending** – Material may be heated to a temperature not exceeding 240^{o}C for a period not exceeding 30 minutes to facilitate bending, unless cold bending is required to retain the original mechanical properties of the material furnished.

c. **Rivet and Bolt Holes** – Rivet and bolt holes shall be drilled to finished size or subpunched smaller than the nominal diameter of the fastener and reamed to size. The amount by which the diameter of a subpunched hole is smaller than that of the finished hole shall be at least one-quarter the thickness of the piece. The finished diameter of holes shall be not more than 7% greater than the nominal diameter of the fastener except:

   i. Slotted bolt holes to take care of expansion shall be provided as called for on the Drawings.
   ii. Anchor bolts holes may be up to 25% greater than the nominal bolt diameter with a maximum of 12.7 mm greater than the nominal bolt diameter.

d. **Contact with other Materials** – Where Aluminum alloys come in contact with other metals, except stainless steel, the contacting surfaces shall be thoroughly coated with an Aluminum-impregnated caulking compound, or a synthetic rubber gasket may be placed between the two surfaces. Aluminum alloys shall not be placed between the two surfaces. Aluminum alloys shall not be placed in contact with copper, copper base alloys, lead or nickel.

   Where Aluminum alloys come in contact with concrete, bearing pads as specified in Clause 1303 of these Specifications or as indicated on the Drawings shall be provided.

1205.04 REQUIRED INFORMATION

The Contractor shall give the name and address of the factories at which the required materials will be manufactured for the approval of the Engineer.

Before an order is placed with the manufacturers, the Contractor shall submit the following, in English Language, to the Engineer for his approval.

a. Detailed drawings for all the offered materials complete with all technical information, catalogues etc.

b. Tabulations showing:
   i. The overall dimensions of each type and size of the offered material.
   ii. The chemical composition of the various alloys components and the quality of metal used for the offered material.

c. A certified program of delivery from manufacurer.

1205.05 MEASUREMENT AND PAYMENT FOR RAILING

1205.05.1 Method of Measurement and Basis of Payment

Railing shall be measured by the linear meter from center to center of supports, measured along the line and grade of the railing.

Payment for railing shall be at the rate included in the Bills of Quantities which price shall be full compensation for all labour, materials, tools, equipment and incidentals and doing all work necessary for the construction of the railing, complete in place, as specified and as required. No other compensation will be allowed.

1205.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1205.1	Railing	m

1206 - ENERGY ABSORBING TERMINAL (E.A.T.) SYSTEMS

1206.01 GENERAL

Energy Absorbing Terminal Systems, permanent and portable , shall be provided for protection of traffic as shown on the Contract Drawings. When E.A.T. Systems are referred to in this Clause, it shall also include portable E.A.T. systems except for certain Clauses in Section 18 (Maintenance and Protection of Traffic) of these Specifications which specifically relate to portable E.A.T. System.

The systems shall be of a commercially available design having a proven record of satisfactory performance for at least five years. Satisfactory documentary evidence shall be provided by the Contractor at least 90 days prior to his requirement to order materials for the system. The evidence shall show that the system he proposes meets the requirements specified herein and that it has been successfully tested following the procedures set forth in U.S. Department of Transportation Research Report NCHRP No. 350 or BS EN 1317-3:

1206.02 REQUIREMENTS OF THE SYSTEM

a. **General Characteristics** – The systems shall be able to withstand head-on and side impacts within the design criteria specified herein and shall have all the performance characteristics of a conventional metal beam guardrail (strength, durability, redirectional properties etc) with a low maintenance requirement. The system shall exhibit anti-climb characteristics.

   The systems shall be suitable for use in the climatic conditions of Kuwait and the energy absorbing cartridges or units and other components of the system shall not be liable to damage or deterioration from high temperatures or by prolonged exposure to direct sunlight.

b. **Reusability** – The systems shall be such that most major system components can be reused after a typical impact.

   When impacted, complete refurbishment of either system must be possible within 24 hours.

c. **Head-On Impact** – The systems shall be designed to fit within the areas allocated on the Drawings and shall reduce average G forces to approximately 6.80 or less when impacted by a vehicle weighing between 820 and 2000 kg, traveling at the appropriate design speed.

d. **Side Impact** – The systems shall be designed such that any vehicle within the 820 to 2000 kg weight range, impacting at any point along the side and at angles up to twenty (20) degrees as measured from the longitudinal center line, will be redirected at an exit angle of approximately twelve (12) degrees or

less measured from the side of the system. The speed for impact shall be the design speed or 100kph whichever is greater.

e. **Debris** – Debris from the replaceable energy absorbing cartridges or units, after head-on or side impact, shall be retained within the cartridge or units. The system shall be designed so that no parts fly loose on impact.

f. **Materials**

1. Metal Work – All metal work shall conform to Section 12 (Metal Works) of these Specifications and shall be hot dipped galvanized in accordance with Clause 1201.05 of the Specifications.
2. Concrete Works – All concrete work shall conform to Section 5 (Concrete Works) of these Specifications.
3. Other Materials – Other materials used in E.A.T. systems shall conform to recognized International Standards for such materials in the proposed usage and conditions and shall be subject to approval by the Engineer. The Contractor shall supply all necessary certification to satisfy the Engineer that the offered materials are suitable for the intended usage.

1206.03 DRAWINGS

The Contract Drawings indicate locations for E.A.T. systems. When a particular system has been approved it shall be used for all locations specified throughout the Contract.

1206.04 DETAILED DESIGN SUBMISSION

The Contractor shall within 30 days after the Date of enterprise, submit for the approval of the Engineer detailed design calculations, descriptions and specifications of the individual elements of the system, the full installation procedures, fixing details, and all other data considered necessary by the Engineer to assess the proposed system, including fully dimensioned scale layout drawings.

No work or fabrication of the system or ordering of materials shall be carried out until the Engineer has given his approval in writing to the Contractor's Detailed Submission.

1206.05 INSTALLATION

The E.A.T. system shall be installed and approved by the Engineer before any section or roadway is opened to traffic either as permanent works or as part of the maintenance of traffic arrangements specified in Section 18 (Maintenance and Protection of Traffic) of these Specifications. Where permanent works are to be incorporated as part of detours, the Engineer may allow at his discretion, the use of a portable E.A.T. system in place of a permanent installation required for the final works. The installation procedures, equipment and materials shall strictly be in accordance with the recommendations of the E.A.T. system manufacturer, and shall be carried out or supervised by workmen approved by the systems manufacturer who are experienced in the installation of the system. The Contractor shall provide documentary evidence that these conditions are implemented.

1206.06 REPAIR OF DAMAGED E.A.T. SYSTEMS

In the event an E.A.T. system is damaged by any cause whatsoever prior to issuance of Final Completion Certificate, the Contractor shall replace, repair or restore the damaged portion to the satisfaction of the Engineer within 24 hours of notification from the Engineer.

Spare parts for such repairs may be taken from the relevant E.A.T. system Spare Parts Sets; however, all such parts used for repairs shall be promptly replaced by the Contractor.

1206.07 PENALTY FOR FAILURE TO RESTORE E.A.T. SYSTEMS

In the event the Contractor fails to restore any damaged E.A.T. system, within 24 hours after being notified by the Engineer (unless a time extension is approved by the Engineer), the Contractor shall incur a penalty of

Kuwaiti Dinars Two Hundred and Fifty (KD 250/-) per day or part of the day for each damaged E.A.T. system until such E.A.T. system is restored to the satisfaction or the Engineer.

1206.08 MANUALS

The Contractor shall supply the Engineer with 6 English and 6 Arabic copies of Installation and Maintenance Manuals for each system 90 days before ordering the system.

1206.09 SPARE PARTS

The Contractor shall complete the relevant Spare Parts Lists (Sample in Appendix A) for E.A.T. contained in this Section of the Specifications and submit these Lists with his Tender to show the E.A.T. system manufacturer's recommended set of spare parts needed to restore an E.A.T system to its original condition after a head-on impact at the design speed . The Spare Parts List shall include two unit rates: one for supply of the parts only and another for supply and installation of the parts including labour, equipment and sundry materials.

The number of required sets of spare parts is shown in the Bills of Quantities however, the Employer shall have the right with proper notice to require the Contractor to provide whatever quantities of each listed spare part as he may require at the unit rates given on the Spare Parts List.

The Contractor shall have the number of sets of spare parts shown in the Bills of Quantities on hand prior to placing any permanent or portable E.A.T. units in service. During the period of construction (refer also to Section 18 (Maintenance and Protection of Traffic) of these Specifications, any spare parts removed and used by the Contractor from the spare parts sets to repair damaged E.A.T. systems shall promptly be replaced.

All spare part sets shall contain all the parts listed in the Spare Parts List at the date of issuance of the Certificate of Final Completion and shall become the property of the Employer.

1206.10 REPAIR OF DAMAGED E.A.T SYSTEMS

No separate measurement or payment will be made for repair of E.A.T. systems damaged by any cause whatsoever, up until the date of Substantial Completion of that part of the works in which a damaged E.A.T. system is located. Following the date of Substantial Completion, repair of E.A.T. systems damaged by any cause other than fault of the Contractor shall be paid for by the Employer. E.A.T. system spare parts and installation shall be reimbursed at the relevant unit rate (s) shown in the Spare Parts Lists for each individual part needed in making the repair(s).

1206.11 MEASUREMENT AND PAYMENT FOR PERMANENT E.A.T. SYSTEMS

1206.11.1 Method of Measurement and Basis of Payment

Measurement for E.A.T. systems shall be by number. Payment for each complete E.A.T. system installed shall be at the rate shown in Section 12of the Bills of Quantities, the rate shall include detailed design submission, supply and installation of the complete system including all necessary materials (including pad and backup wall for E.A.T. system Type II), labour, tools, equipment and appurtenances, and supplying installation and maintenance manuals to the Engineer as specified herein.

Measurement of sets of Spare Parts shall be by the number of sets and each set shall include all of the spare parts listed on the Spare Parts Lists.

Payment for each set of spare parts shall be the total amount entered by the Tenderer at the bottom of the Spare Parts Lists for each set and as transferred to the item in the Bills of Quantities.

Measurement for individual parts shown in the Spare Parts Lists shall be by number each such part required.

Payment for individual spare parts that the Engineer determines are required (plus or minus the quantities shown on each Spare Parts List) shall be by the number of each spare part at the unit rate inserted against the individual part on the Spare Parts List.

The rates for complete sets of spare parts or for individual spare parts ordered by the Engineer shall include full compensation for the supply, delivery to Kuwait, clearance and delivery, off-loading and placing materials, etc., in storage at the Ministry of Public Works (MPW) store or other location as determined by the Engineer, complete, and with all appurtenances

1206.11.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1206.1	Permanent EAT System	nr
1206.2	Spare parts of E.A.T. Systems (Supply only)	nr
1206.3	Spare parts of E.A.T. Systems (Supply and Install)	nr

APPENDIX A (SAMPLE) Spare Parts List

Spare Part No.	Description	Quantity	Unit Rate For Supply KD	Unit Rate For Supply & Install KD

A.1 Basis of Payment

Enter in Bills of Quantities

a. Total Cost Per Set of Spare Part of E.A.T. Systems for Supply KD ----------

b. Total Cost Per Set of Spare Part of E.A.T. Systems for Supply & Install KD ----------

Anticipated delivery period ----------

SECTION 13: BEARINGS, EXPANSION AND FIXED JOINTS

1300 - GENERAL

1300.01 SCOPE

This work shall consist of furnishing all required materials and the installation of elastomeric bearings, pot bearings, fabric bearing pads, elastomeric expansion joints, and preformed expansion joint seals, asphaltic plug expansion joint, all in accordance with the details shown on the Drawings, as herein specified, and as directed by the Engineer. The furnishing and installation or application of all necessary hardware including structural steel angles, anchor bolts and studs, sealants, adhesives, epoxies, and other accessories are included in this work.

1300.02 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

A 36 M	Structural Steel
A 123 M	Zinc (Hot-Galvanised) Coating on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strip.
A 153 M	Zinc Coating (Hop Dip) on Iron and Steel Hardware
A 588 M	High-Strength Low-Alloy Structural Steel with 345 MPa Minimum Yield Point to 100-mm Thick.
A 1011 M	Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
D 395	Test Methods for Rubber Property – Compress Set
D 412	Test Methods for Vulcanized Rubber and Thermoplastic Elastomers Tension
D 471	Standard Test Method for Rubber Property-Effect of Liquids
D 1149	Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber
D 2240	Test Method for Rubber Property Durometer Hardness

AASHTO

AASHTO LRFD Bridge Design Specifications

AASHTO LRFD Bridge Construction Specifications

M 220	Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements

BS

BS 970	Part 2 Wrought Steels in the Form of Blooms, Billets and Forgings
BS EN 13043	Aggregate for Bituminous Mixture and Surface Treatment for Roads, Airfields and Other Trafficked Areas

Eurocode

- CEN prEN 1337-1 Structural Bearings - General Design Rules
- CEN prEN 1337-2 Structural Bearings - Sliding Elements.
- CEN prEN 1337-3 Structural Bearings - Elastomeric Bearings.
- CEN prEN 1337-5 Structural Bearings - Pot Bearings.
- CEN prEN 1337-9 Structural Bearings - Protection.
- CEN prEN 1337-10 Structural Bearings - Inspection and Maintenance.
- CEN prEN 1337-11 Transport, Storage and Installation.
- CEN prEN 1337-12 Structural Bearings - Maintenance and Replacement

1301 - ELASTOMERIC BEARINGS

1301.01 GENERAL

Elastomeric bearing pads shall conform to these Specifications and the requirements shown on the Drawings.

Each bearing shall have an individual distinguishing number.

1301.02 DESIGN

The design of elastomeric bearings shall be in accordance with AASHTO LRFD Bridge Design Specifications.

1301.03 MATERIALS AND MANUFACTURE

The materials and manufacture of elastomeric bearings shall be in accordance with AASHTO LRFD Bridge Construction Specifications, except that in both Tables A and B the “Ozone Test” shall be for 100 hours with 50 pphm and the “Low Temperature Test” will not be required.

Alternatively elastomeric bearings may be designed and manufactured in accordance with CEN prEN 1337-3 Structural Bearings - Elastomeric Bearings

1301.04 QUALITY CONTROL AND TESTING

The manufacturer shall carry out the quality control tests on every batch of elastomer to ensure that the elastomer in the completed bearings complies with these Specifications. These tests shall be carried out by an accredited testing agency.

Materials for elastomeric bearings and the finished bearings themselves shall be subjected to the tests described in AASHTO LRFD Bridge Construction Specifications Article 18.2.5. Material tests shall be in accordance with either Table 18.2.3.1-1 or Table 18.2.3.1-2, as appropriate. Frequency of Testing shall be as specified in Article 18.2.5.2.

Short-duration compression tests on bearings shall be as described in AASHTO LRFD Bridge Construction Specifications Article 18.2.5.6 except that the compression load shall be 200 percent of the rated service load.

Shear testing on finished bearings shall be as described in AASHTO LRFD Bridge Construction Specifications Article 18.2.5.8 at constant compression loads of 50 and 100 percent of the rated service load.

Where elastomeric bearings are equipped with sliding surface of polytetrafluorethylene (PTFE) and stainless steel mating surface, the PTFE shall be as specified in AASHTO LRFD Bridge Construction Specifications Article 18.8.2..

Certified copies of the results from shear resistance tests shall be provided for the Engineer. In addition certified test results on 10 percent of the batches of elastomer used in the manufacture of the bearings, with a minimum of 3 samples, shall also be provided.

1301.04.1 PTFE Bearing Surfaces

Prefabricated expansion bearings having working surfaces of PTFE shall conform to the design, material, manufacturing and test requirements of AASHTO LRFD Bridge Design Specifications and AASHTO LRFD Bridge Construction Specifications except as modified herein.

The PTFE plate shall be continuously lubricated.

At least one of each bearing type shall be tested for friction in accordance with the Specifications.

1301.05 HANDLING, STORAGE AND FIXING

Bearings shall be carefully handled and stored so as to protect them from damage at all times.

Bearings shall be installed on an epoxy or cement mortar bed, as shown on the Drawings, in such a way that they are in contact over the whole area of their base.

The installed bearings shall be within ±3mm of their correct position in all directions and be level to within ±0.1° in any direction.

1301.06 MEASUREMENT AND PAYMENT

1301.06.1 Method of Measurement and Basis of Payment

The furnishing and installing of elastomeric bearings shall be measured by number of each type separately stating the vertical and horizontal loads. Payment shall be made at the rates inserted in the Bills of Quantities which rates shall include for all labour, materials, equipment, incidentals and testing necessary to complete the installation of the elastomeric bearings.

1301.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1301.1	Elastomeric Bearing (type), vertical and horizontal loads (kN)	nr

1302 - POT BEARINGS

1302.01 GENERAL

Pot type fixed and expansion bearings shall conform to these Specifications and to the requirements shown on the Drawings.

For both fixed and sliding bearings the required articulation shall be provided by means of an elastomeric pot unit. For sliding bearings the sliding surfaces supporting the vertical load shall consist of stainless steel sliding on pure dimpled PTFE, lubricated. For guided bearings the sliding surfaces resisting horizontal forces shall consist of stainless steel sliding on approved plain or composite PTFE surfaces.

With the exception of the elastomer insert and the facings to the sliding surfaces pot type fixed and expansion bearings shall be fabricated from steel or malleable cast iron.

Each bearing shall have an individual distinguishing number.

1302.01.1 Quality Assurance

Before an order is placed for the supply of bearings, the Contractor shall submit to the Engineer for approval, the name and address of the bearing manufacturer. The proposed organisation named shall submit evidence that it has, for a period of at least five years, manufactured bearings comparable to those required under the Contract, and shall verify this experience by citing at least two projects which have successfully employed bearings comparable to those required on this project.

1302.01.2 Submittals

a. Shop drawings shall be submitted to the Engineer for approval.

b. Certificates from the manufacturer shall be furnished stating that the materials to be provided conform to the Specification requirements.

c. Test Reports. The Contractor shall furnish to the Engineer, reports of material and load tests as specified herein, or as further requested by the Engineer.

1302.02 DESIGN

Steel or iron components of the bearing shall be designed in accordance with AASHTO LRFD Bridge Design Specifications.

The maximum stress on the elastomer in the pot shall not be more than 40 N/mm^2 and the thickness of the elastomer shall be such that the maximum strain under maximum rotation does not exceed 15%. A sealing

device shall be provided which shall prevent the elastomer extruding under the design load.

The dimpled PTFE supporting the vertical loads shall be retained in position by recessing into its backing plate. The thickness and projection of the PTFE shall be as given in Table 1302.02.a.

Maximum Dimensions of PTFE (Diameter or Diagonal)	Minimum Thickness	Protection above recess
up to 600 mm	4.5 mm	2.0 mm
over 600 to 1200 mm	5.0 mm	2.5 mm
over 1200 to 1500 mm	6.0 mm	3.0 mm

Table 1302.02.a – Dimensions of Recessed PTFE

The maximum average pressure on the PTFE (without deduction for lubrication cavities) shall not be more than 30 N/mm^2 for permanent loads, nor more than 45 N/mm^2 for all loads.

The stainless steel surface shall be above the PTFE surface in the bearing and shall overlap it at all times. The minimum thickness of the stainless steel shall be related to the difference between the PTFE and stainless steel dimension in the direction of movement as given in Table 1302.02.b.

Dimensional Difference between PTFE and Stainless Steel	Minimum Thickness of Stainless Steel
up to 300 mm	1.5 mm
over 300 to 500 mm	2.0 mm
over 500 to 1500 mm	3.0 mm

Table 1302.02.b – Thickness of Stainless Steel Sheet

The stainless steel sheet shall be attached to its backing plate by continuous welding along the edges or by fasteners supplemented by either peripheral sealing or full area bonding. The method adopted, to be approved by the Engineer, shall ensure that the stainless steel sheet remains flat throughout its service life and interface corrosion cannot occur.

The pressure transmitted to the concrete shall be in accordance with AASHTO LRFD Bridge Design Specifications.

The PTFE facings to guides shall be attached either by recessing or bonding or suitable mechanical means or by a combination or these to the approval of the Engineer.

The maximum pressure on glass filled PTFE shall not be more than 45 N/mm^2 and the maximum pressure on PTFE in a metal matrix shall not be more than 60 N/mm^2. The pressure on other types of PTFE on guides shall be to the Engineer's approval having due regard to the method of fixing.

The stainless steel mating surface on guides shall overlap the PTFE surface at all times.

1302.03 MATERIALS AND MANUFACTURE

The materials and manufacture of the steel and iron components of the bearings shall be in accordance with the relevant clauses of AASHTO LRFD Bridge Construction Specifications. The elastomer component of the pot shall be in accordance with Clause 1301.03 of these Specifications except that the nominal hardness shall not be greater than 60. The PTFE and stainless steel bearing surfaces shall be in accordance with AASHTO LRFD Bridge Construction Specifications.

Dimpled PTFE shall have lubrication cavities with a plan area between 10% and 30% of the total PTFE bearing surface, a volume between 3% and 20% of the gross volume exposed above the retaining recess and a depth not exceeding half the depth of the PTFE sheet nor the height of its projection above the retaining recess. The temperature for hot pressing the cavities shall not exceed 200°C. Before final assembly of the bearings the dimples shall be filled with an approved lubricant.

All exposed bearing surfaces, except for those which will be in contact with the structure, shall be given an approved protective treatment to the manufacturer's recommendations.

1302.04 QUALITY CONTROL AND TESTING

The manufacturer shall maintain a system of factory control and inspection to ensure that the completed bearings comply with these Specifications to the satisfaction of the Engineer.

Testing of complete bearings shall comprise the following:

Dimension Check: the dimensions of the bearings shall be checked in accordance with AASHTO LRFD Bridge Construction Specifications Article 18.1.5.2.4.

Clearance Test: in accordance with AASHTO LRFD Bridge Construction Specifications Article 18.1.5.2.5.

Bearing Friction Test: in accordance with AASHTO LRFD Bridge Construction Specifications Article 18.1.5.2.6. In addition to the compression of 100 percent of the full service dead load plus live load, the bearings shall be checked for 50 percent and 80 percent of the full service dead load plus live load.

Bearing Horizontal Force Capacity: in accordance with AASHTO LRFD Bridge Construction Specifications Article 18.1.5.2.8. Failure or excessive deflection of any of the components shall be cause for rejection.

Vertical Load Test: bearings shall be tested for vertical load equal to one and a half (1.5) times the full service dead load plus live load. The test shall be applied in five equal increments and the test load held for one (1) hour or until deformation ceases, whichever is the greater. The load shall then be removed in equal decrements as the load increments. A second cycle of load increment and decrement shall be applied with the maximum test load being held for (30) minutes. The load-deformation graph shall be plotted for both load cycles and the set determined. If the set exceeds a value deemed to be excessive by the Engineer, the Engineer may require all bearings to be pre-loaded before installation. At the end of the vertical load test, the bearing shall be dismantled and the bearing surfaces examined. Damage to the naked eye on disassembly of the bearing, such as excessive wear, cracks, or splits in the material shall be cause for rejection.

If one bearing of the sample fails, all the bearings of that lot shall be rejected, unless the manufacturer elects to test each bearing of the lot at his expense. In lieu of this procedure, the Engineer may require every bearing of the lot to be tested.

The Engineer may dispense with load testing if the manufacturer can produce results of a similar test independently witnessed on a bearing of similar design.

1302.05 HANDLING, STORAGE AND INSTALLATION

Bearings shall be clamped together before leaving the factory and shall not be taken apart unless ordered by the Engineer in writing. They shall be carefully handled and stored so as to be protected from damage at all times.

Bearings shall be installed in the structure on a cement or epoxy mortar bed as shown on the Drawings. The method of installation shall be such that the bearing is in full contact with the mortar bed over the whole of the area of the base plate. If any temporary levelling devices are used, their design and use shall be such that there is no danger of them remaining in contact with the bearing after installation.

The installed bearings shall be located so that they are within 3 mm of their correct position in all directions and level to within 0.1° in any direction. Guided bearings shall be placed with their guide bars within 0.2° of their correct angular bearing.

All temporary clamping devices shall be removed after the superstructure is fixed above the bearings, as instructed by the Engineer.

1302.06 MEASUREMENT AND PAYMENT

1302.06.01 Method of Measurement and Basis of Payment

The furnishing and installing of pot bearings shall be measured by number of each type separately stating the vertical and horizontal loads and the amount of movement. Payment shall be made at the rates inserted in the Bills of Quantities and such rates shall include for all labour, materials, equipment, load testing and incidentals necessary to complete the installation of the pot bearings.

1302.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1302.1	Pot Bearing (type), vertical and horizontal loads (kN), movement (mm)	nr

1303 - FABRIC BEARING PADS

Fabric bearing pads shall consist of a fabric and rubber body made with new unvulcanized rubber and unused fabric fibres.

The rubber body shall be a natural rubber compound known as natural polyisoprene or synthetic rubber known as polychloroprene.

The average surface hardness expressed in standard rubber hardness shall be 80 +10 Shore A Durometer.

The ultimate breakdown limit of the pad under compressive loading shall not be less than 493 kg/cm2 for the specified thickness without extrusion or detrimental reduction of thickness.

The pads shall be furnished to specified dimensions with all dowel holes accurately located.

The thickness of fabric bearing pads shall be as shown on the Drawings within a tolerance of + 1.0 mm.

1303.01 MEASUREMENT AND PAYMENT

1303.01.1 Method of Measurement and Basis of Payment

The furnishing and installing of fabric bearing pads shall be measured by number stating the vertical and horizontal loads. Payment shall be made at the rates inserted in the Bills of Quantities which rates shall include for all labour, materials, equipment, incidentals and testing necessary to complete the installation of the elastomeric bearings.

1303.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1303.1	Fabric Bearing Pads, vertical and horizontal loads (kN)	nr

1304 - ELASTOMERIC EXPANSION JOINTS

1304.01 GENERAL

The elastomeric expansion joints shall be an integrally moulded unit of neoprene and bonded steel. The elastomeric joint shall conform to the details shown on the Drawings and shall meet the material requirements as specified herein. Prior to approval of the neoprene joint to be used, the Contractor shall submit a certification by the manufacturer, stating that the joint and the accessory items meet the requirements of these Specifications. The Engineer may request the Contractor to furnish whatever samples may be required to perform any of the tests specified as necessary to qualify the material. Acceptance of the joint to be used in the work shall be subject to written approval from the Engineer.

1304.02 REQUIREMENTS

The elastomeric expansion joint shall consist of integrally moulded units of neoprene and bonded steel components so arranged as to provide for the expansion and contraction movements of the bridge deck with one of the steel components bridging the joint gap and of sufficient strength to carry wheel loads across the joint.

The expansion joints shall seal the deck surface to prevent moisture and other contaminants from descending onto the pier and abutment caps and shall have provision for adequate anchoring of the joint assembly to the

bridge deck. There shall be no appreciable change in the deck surface with the bridge expansion and contraction movements. All the expansion and contraction movements of the bridge deck shall be taken entirely by deformation of the neoprene.

The sizes of elastomeric expansion joints shown on the Drawings have been specified according to the expected movement of the concrete superstructures due to shrinkage and creep of concrete, temperature change and live load.

The dimensions of the neoprene portion of the elastomeric joint shall be correct to 0 mm under and plus 6 mm over in width and length, and from 0 mm under to plus 3 mm over in thickness of the exterior dimensions required on the Drawings measured at 20°C.

Factory-made kerb units shall be provided at kerbs. In the case of skew joints where the skew exceeds 7.5° the kerb units shall be specially detailed and fabricated to suit each individual joint.

1304.03 MATERIALS

1304.03.1 General

All ancillary materials, e.g. sealants, bedding material, etc., shall meet the properties stated by their manufacturer and be recommended by the manufacturer of the neoprene joint as being suitable for their purpose.

1304.03.2 Elastomer

The elastomer portion of the expansion joints shall be of the compound known as “Neoprene” which shall have the following physical properties as determined by the following ASTM requirements.

Property	ASTM Test	Requirement
Tensile Strength (min)	D 412	125 kg/cm^2
Elongation at Break |(min)	D 412	350 %
Hardness	D 2240	Minimum 45 points Durometer A
Compression Set: (max) 22 Hours at 70◦C	D 395 Method B	35%
Exposure to 100 pphm ozone For 70 hours @ 38◦C sample Under 20 strain	D1149	No Cracks
Oil Deterioration Volume increase after Immersion in ASTM Oil #3 For 70 hours @ 100◦ C (max)	D 471	120%

Table 1304.03.2 – Properties of Elastomer

1304.03.3 Steel

All structural steel for use in elastomeric expansion joints shall conform to the requirements of ASTM A36M or A1011M, or as shown on the Drawings.

Structural steel angles and anchors if used shall be fabricated and hot dip galvanised in accordance with the requirements of ASTM A123M and of Section 12 (Metal Works) of these Specifications.

1304.03.4 Sealants

a. The sealant for sealing joints between the expansion joint units, shall be a high solids, two-part, polyurethane or polysulphide based sealant meeting the requirements of Clause 504.04.4 of Section 5

(Concrete Works) of these Specifications and that cures quickly, without shrinkage, into a rubber with high elongation characteristics and excellent "memory". It shall be capable of bonding to concrete, steel, and neoprene, if necessary with the use of a primer. When cured, the sealant shall possess excellent abrasion resistance and shall resist attack by salt, oil and road chemicals. The sealant shall be recommended by the manufacturer of the neoprene expansion joint.

b. Sealant for bedding units on to the prepared bed shall be a product which will ensure a water-tight seal, which is recommended by the manufacturer of the expansion joint and which can be demonstrated to have been used extensively and successfully for this application in similar conditions.

c. Sealant for filling the void space around the nuts shall be a material recommended by the manufacturer of the joint and shall be compatible with and have physical characteristics when cured similar to the neoprene of the joint.

1304.04 FIXING OF EXPANSION JOINTS

Fixing of expansion joints shall be by means of either commercial grade anchor bolts hot dip galvanised in accordance with ASTM A153M, or stainless steel studs manufactured from free-machining 18/A Austenitic chromium nickel steel to BS 970 Part 4.

Bolts or studs shall be set in pre-drilled holes in the deck concrete in accordance with approved shop drawings. The holes shall not be drilled until a minimum of 7 days has elapsed since placing of the concrete. The position of the holes shall be accurately located by means of a template.

1304.05 INSTALLATION OF EXPANSION JOINTS

The Contractor shall obtain installation instructions from the supplier of the expansion joint material and comply with the procedures specified in the installation of the joint. Shop drawings shall be submitted to the Engineer for approval. The adequacy of the joint design and installation details shall meet with the approval of the Engineer and his decisions shall be final.

The Contractor shall obtain the technical assistance of a field representative from the manufacturer of the joint during its installation.

Joint assemblies shall be installed as shown on the Drawings and as approved by the Engineer.

In post-tensioned pre-stressed concrete works installation shall not be carried out until at least 40 days have elapsed following completion of the post-tensioning operation.

Proper adjustment shall be made when setting the joints for the temperature at the time of installation as shown on the Drawings.

The finished joint shall present a smooth, neat appearance with no protruding bolts or studs or rough joints. Excess sealant shall be wiped or scraped away before it becomes hard. Upon completion of an entire joint the Contractor shall grind any uneven end butt connections flush.

The Contractor shall prevent all construction traffic from crossing the joint until such time as the joint assembly has been installed and all materials have properly cured.

1304.06 METHOD OF MEASUREMENT AND PAYMENT

1304.06.1 Method of Measurement and Basis of Payment

The method of measurement for Elastomeric Expansion Joints shall be by the metre run measured along the centreline of the joint for each type or size. Payment shall be at the rate included in the Bills of Quantities which rate shall include, but not by way of limitation, furnishing all materials and installing hardware, including kerb and gutter units, and transition strips as specified herein for elastomeric expansion joints complete in place, in accordance with the Drawings, Specifications and instructions of the Engineer.

1304.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1304.1	Elastomeric Expansion Joint (type or size)	m

1305 - PREFORMED EXPANSION JOINT SEALS

1305.01 GENERAL

This work shall consist of furnishing all required material, the application of the approved adhesive, and the installation of the preformed sealer, as shown on the Drawings, herein specified, and as directed by the Engineer.

The furnishing and installation of all hardware, including structural steel angles, anchors and other accessories are included in this work.

1305.02 MATERIALS

The joint sealer shall be of a neoprene, preformed or extruded type, of essentially the size and shape shown on the Drawings. The preformed joint sealer material shall comply with the requirements of AASHTO M220. The joint sealer shall be such that it will repel the intrusion of stones, dirt, etc., into the joint or into the material itself.

The sealer shall be so shaped that when installed, at minimum joint opening it shall be compressed to 80% of its movement capability. It shall also be so shaped that in its compressed condition the top centre of the exposed surface shall be depressed below the surface of the installed sealer. The sealer shall be furnished in a sufficient width to accomplish this kind of closure. The shape to be used and the width and depth to be furnished shall have prior approval of the Engineer. It shall be flexible and pliable and retain its elasticity at temperatures from 80^0 C to -28^0 C and shall not develop appreciable permanent set after full compression of the approved joint shape for the full effective life of the material. It shall be compatible with the material of which the joint surfaces are composed and be relatively unaffected by the normal moisture in the material.

All structural steel for use in the preformed expansion joint shall conform to the requirements of ASTM A588M, and as specified in Section 12 (Metal Works) of these Specifications for fabrication and welding.

Each lot of the joint filler shall be identified with the manufacturer's name or trade mark and shall be accompanied by the manufacturer's Certificate of Compliance confirming conformance with these Specifications.

Each lot of the adhesive shall be delivered in containers plainly marked with the manufacturer's affidavit attesting conformance with these Specifications.

1305.03 CONSTRUCTION DETAILS

The sealer shall be installed by suitable hand or machine tools and thoroughly secured in place with an approved adhesive which shall cover both sides of the sealer over the full area in contact with the sides of the joint. The adhesive may be applied to the sides of the joint or the sealer or both. The sealer shall be installed in a compressed condition and shall at all times be below the level of the surface by approximately the amount shown on the Drawings. The sealer shall be in one continuous piece for the full width of the transverse joint prior to being installed in the joint. The continuous piece for installation may have not more than one butt splice within its length. The butt splice shall be a manufacturer's splice. If this splice is torn or damaged it shall be repaired, prior to installation, using the manufacturer's recommended adhesive. In longitudinal joints the sealer shall be in practical lengths. Any joints in the sealer material shall be adequately sealed with additional adhesive.

The sealer may be installed immediately after the removal of the curing cover using an adhesive that is compatible with the sealer and the material of which the joint surfaces are composed. Temperature limitations of the adhesive as guaranteed by the manufacturer shall be observed. Joints shall be clean and free from foreign material immediately prior to the installation of the sealer.

1305.04 APPROVAL OF SEALS

No shipment of materials shall be accepted for use unless the material complies with the requirements of these Specifications.

The materials shall not be used until the Contractor has been notified by the Engineer that they meet the requirements of the Specifications.

1305.05 MEASUREMENT AND PAYMENT

1305.05.1 Method of Measurement and Basis of Payment

The method of measurement for Preformed Expansion Joint Seals shall be by the metre run measured along the centreline of joint for each type or size. Payment shall be at the rate included in the Bills of Quantities which rate shall include, but not by way of limitation, furnishing all materials as specified herein and shown on the Drawings and installing the Preformed Expansion Joint Seal, complete in place, in accordance with the Drawings, Specifications and instructions of the Engineer.

1305.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1305.1	Preformed Expansion Joint (type or size)	m

1306 - ASPHALTIC PLUG EXPANSION JOINTS

1306.01 GENERAL

This work shall consist of furnishing all required material, the application of the approved adhesive, and the installation of asphaltic plug joints as shown on the Drawings, herein specified, and as directed by the Engineer.

1306.02 MATERIALS

Binder:

The binder used in the construction of an asphaltic plug joint must have the following characteristics:

- remain flexible in cold conditions,
- be stable in hot conditions,
- be flow resistant.

The following tests should be carried out by an approved laboratory at the temperatures stated in the Contract Documents, and a certificate issued in not less than 12 months before start of the Contract:

- Extension Test,
- Softening Point Test,
- Flow Resistance Test.

Stone: The stone will be single-sized 20 mm aggregate to BSEN 13043 . It shall be a clean, dry stone, pre-bagged to avoid contamination. It shall be a stone with a polished stone value of 60, and a maximum flakiness index of 25.

1306.03 METHOD OF MEASUREMENT AND PAYMENT

1306.03.1 Method of Measurement and Basis of Payment

The method of measurement for Asphaltic Plug Expansion Joints shall be by the meter run measured along the centerline of the joint. Payment shall be at the rate included in the Bills of Quantities which rate shall include, but not by way of limitation, furnishing all materials and installing all necessary hardware specified by the manufacturer for asphaltic plug expansion joints complete in place, in accordance with the Drawings, Specifications and instructions of the Engineer.

1306.03.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1306.1	Asphaltic Plug Joint	m

SECTION 14: LIGHTING AND ELECTRICAL WORKS

1400 - GENERAL

1400.01 SCOPE

This Section contains the specifications for street lighting and electrical works which is prepared and issued by the Ministry of Electricity and Water (MEW), Kuwait, and consists of furnishing, installing, testing, commissioning and maintaining street lighting systems, sign lighting systems, undercrossing lighting, cables, conduits, control equipment, earthing, power supply and appurtenant work, including all related civil works, as specified herein and as directed by the MEW/Engineer.

It is the Contractor's responsibility to check that the equipment he proposes to supply will achieve for the roads shown on the Drawings the lighting criteria specified in Clause 1412.01 and Clause 1414.06 of these Specifications. Any additional equipment required to achieve these criteria shall be furnished and installed by the Contractor at no additional cost to the Employer.

The street lighting installations shall be provided with energy saving features by employing dual power dimming ballasts and power switching devices including all wiring/cabling from the lighting control cabinets/feeder pillars to the lighting units in order to centrally and automatically control the lumens output to dim from 100% to 50% at a pre-set time during the night and back to full lumens output at early morning through an astronomical time switch installed at the lighting control cabinets/feeder pillars. Since the Contractor has to provide therefore all these additional equipment, wiring/cabling, etc. to make the system fully operational with energy saving feature, it is extremely important that he should study the tender Specifications very carefully before submitting his bid for any tender.

1400.02 ROAD LIGHTING – PROVISION AND RESPONSIBILITY

The Contractor shall ensure that all roads within the Site which have existing lighting facilities at the Date of Enterprise are provided with lighting during the hours of darkness for the duration of the Contract.

The requirement to provide lighting at all times shall also apply to new intersections and to detour roads acting as replacements for roads previously lit. The provision of new temporary lighting for detours and the takeover of existing temporary lighting shall be in accordance with Section 18 (Maintenance and Protection of Traffic) of the Specifications.

Lighting shall be provided using the existing or new permanent systems wherever possible. No existing lighting shall be taken out of service until an alternative is approved for operation by the Engineer.

All existing original road lighting within the Limit of Works shall become the Contractor's responsibility from the Date of Enterprise and, not withstanding any other requirements of the Contract Documents, Clause 20 "Care of the Works" of The Conditions of Contract shall particularly apply. On taking over the existing original lighting the Contractor shall inspect the equipment and rectify any minor defects, including but not limited to the replacement of failed lamps, control gear, MCCB/MCBs, fuses etc. and missing equipment such as base compartment doors of lighting colums, to give a fully operational installation except for any lighting units which have been disconnected by Ministry of Electricity and Water.

Subsequently the Contractor shall maintain and operate any original lighting system up to the time it is to be dismantled, including supplying and installing replacement lamps, control gear components etc., as necessary and dismantling and transporting to Ministry of Electricity and Water stores any accidented lighting columns and collecting from Ministry of Electricity and Water store and erecting replacement columns as directed by the MEW/Engineer.

1400.03 MAINTENANCE OF NEW PERMANENT LIGHTING SYSTEMS AFTER COMPLETION

The Contractor shall maintain the entire new permanent lighting systems under the Contract for a period of two (2) complete years from the date of completion of his works as a warranty.

The Contractor shall carry out day and night maintenance and survey patrol on fortnightly basis and hence,

provide one patrol vehicle with driver, one electrician and basket crane and other vehicles as and when necessary for this purpose throughout the maintenance period of the Contract.

The Contractor shall carry out all repair works including attending to and rectifying all faults and damages, howsoever they be caused and shall be responsible for the replacement of all wear and tear items of all equipment. Any parts, accessories, cables, control gears,control cabinets/feeder pillars, lamps, MCB'S/MCCB's etc., which have been put out of service or otherwise damaged due to the Contractor's negligence or which have failed or become defective due to material or manufacturing faults shall be rectified and/or replaced by the Contractor at no extra cost whatsoever.

The Contractor shall dismantle and transport to the Employer's store any accidented lighting column and collect from the store and erect replacement lighting column complete with all accessories as directed by the MEW/Engineer, all at his own expense.

The maintenance works will be supervised by and will be under the full control of the Ministry of Electricity & Water and in case of failure on the part of the Contractor to carry out any maintenance work in a proper manner and on time, penalties will be imposed in accordance with the prevailing terms and conditions stipulated in the Contract Documents.

1400.04 PENALTY FOR FAILURE TO COMPLETE ELECTRICAL RECTIFICATION WORKS

The Contractor shall complete all lighting works, including all rectification works within 90 days of Substantial Completion. In the event the Contractor fails to complete such rectification works to the MEW's /Engineer's approval within the above specified time, he will incur a penalty of Kuwaiti Dinars of One Hundred and fifty (KD. 150/-) per day until the works are completed to the satisfaction of the MEW/Engineer.

1400.05 CONTRACTOR'S LIABILITY FOR FAILURE TO ACHIEVE GUARANTEED LIGHTING LEVELS

In case the field performance tests as stipulated under Clause 1401.11 of these Specifications reveal that the guaranteed levels and uniformities of lighting have not been achieved and are considerably lower than the guaranteed value, the Contractor is liable to supply and install luminaires of higher lighting performance from an MEW approved type and/or to adjust the spacing between the lighting units and to provide all additional lighting units at no extra cost whatsoever.

1401 - REQUIREMENTS FOR LIGHTING AND ELECTRICAL WORKS

1401.01 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM (American Society for Testing and Materials)

A 123 M	Zinc (Hot Galvanised) Coating on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bar and Strip.
A 153 M	Zinc Coating (Hot Dip) on Iron and Steel Hardware
A 307	Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
A 385	Standard Practice for Providing High Quality Zinc Coating (Hot Dip) on Assembled Products
F 1554-07a	Standard Specification for Anchor Bolts, Steel. 36, 55, and 105-ksi Yield Strength

AASHTO (American Association of State Highway and Transportation Officials)

Standard Specification for Structural Supports for Highway Signs, Luminaries, and Traffic Signals

BS (British Standards)

BS 159	Specification for Highvoltage Busbars and Busbar Connections
BS EN 1401-1	Unplasticised PVC Underground Drain Pipe and Fittings
BS EN ISO 1461	Hot Dip Galvanised Coating on Iron and Steel Articles
BS 2484 :1985	Specification for Straight Concrete and Clayware Cable Covers

BS 3506:1969	Unplasticised PVC Pipe for Industrial Uses
BS 4346-2:1970	Joints and Fittings for Use with Unplasticised PVC Pressure Pipes
BS 4678	Cable Trunking
BS 6007	Electric Cables. Heat Resisting Cables for Voltages Up to and Including 450/750 V.
BS 6469	Insulating and Sheathing Materials of Electric Cables
BS 6500	Electric Cables.Flexible Cords Rated Up to 300/500 V for Use With Appliances and Equipment Intended For Domestic, Office and Similar Environments
BS 7655-2.2:1993	Specification for Insulating and Sheathing Materials For Cables. Elastomeric Sheathing Compounds. Heat Resisting Types.
BS 7655-4.2: 2000	Specifications for Insulating and Sheathing Materials for Cables, PVC Sheathing Compounds, General Application.
BS 7668: 2004	Weldable Structural Steels
BS 7919:2001	Electric Cables. Flexible Cables Rated Up to 450/750V for Use With Appliances and Equipment Intended For Industrial and Similar Environments
BS EN 10113-1:	Hot rolled Products in Weldable fine Grain Structural Steels
BS EN 10346:2009	Continuously Hot Dip Steel Flat Products
BS EN 12767	Passive Safety of Support Structures for Road Equipment- Requirements, Classification and Test Methods
BS EN 50164-2:2008	Lightning Protection Components (LPC) - Requirements for Conductors and Earth Electrodes.
BS EN 50214	Flat Polyvinyl Chloride Sheathed Flexible Cables
BS EN 50363-3	Insulating, Sheathing and Covering Materials for Low Voltage Energy Cables. PVC Insulating Compounds.
BS EN 50363-4	Insulating, Sheathing and Covering Materials for Low Voltage Energy Cables. PVC Sheathing Compounds
BS EN 60598	Luminaires Particular Requirements
BS EN 61386-21:2004	Conduit Systems for Cable Management
BS EN 62305	The Protection Against Lightning (Parts 1-4)

CISPR (Comité International Spécial des Perturbations Radioélectroniques)

CISPR 15	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

CIE(Commission Internationale de L'Eclairage)

Publication No.115-1995- Recommendations for the Lighting of Roads for Motor and Pedestrian Traffic
Publication No. 140-2000-Calculations and Measurements of Luminance and Illuminance in Road Lighting

IEC (International Electrotechnical Commission)

60227-1	Polyvynil Chloride Insulated Cables of Rated Voltages Up to and Including 450/750 V
60228	Conductors of Insulated Cables
60502-1	Power Cables with Extruded Insulation and Their Accessories for Rated Voltages from 1 KV (Um = 1.2 kV) up to 30 KV(Um = 36 kV); Part-1: Cables for Rated Voltages of 1 kV (Um=1.2 kV) and 3 KV(Um=3.6 kV).
60529	Classification of Degree of Protection Provided by Enclosures
60598-1	Luminaires - General Requirements and Tests
60598-2-3	Particular Requirements,-- Luminaires for Road and Street Lighting
60598-2-5	Particular Requirements, --Floodlights
60811	Common Test Methods for Insulating and Sheathing Materials of Electric and Optical Cables
60885	Electrical Test Methods for Electric Cables
60898	Circuit Breakers for Over Current Protection for Household and Similar Installations
60923	Ballasts for Discharge Lamps – Performance Requirements
60947	Low Voltage Switchgear and Control Gear:

Part-1:General Rules
Part-2 :Circuit Breakers
Part- 3:Switches, Disconnectors, Switch Disconnectors and Fuse Combination Units
Part-4-1:Contactors and Motor Starters—Electromechanical Contactors and Motor Starters

61048 Capacitors for Use in Tubular Fluorescent and Other Discharge Lamp Circuits,General Safety Requirements
61049 Capacitors for Use in Tubular Fluorescent and Other Discharge Lamp Circuits,Performance Requirements
61167 Metal Halide Lamp
61347 Lamp Control Gear
61439 Low-Voltage Switchgear and Controlgear Assemblies-(Part-1 and Part-2)
61537 Cable Tray and Cable Ladder Systems

ILE(The Institution of Lighting Engineers-UK)

Technical Report Number7 - High Masts for Lighting and CCTV: 2003

ASTA(Association of Short-Circuit Testing Authorities

Testing Certification

Materials and equipment not meeting the requirements of the above standards and codes shall not be used unless approved in writing by the MEW/Engineer.

1401.02 DEFINITION OF TERMS

The following are definitions of terms as used in these Specifications:

Average Illuminance (over a surface) (Eav) – Illuminance averaged over the specified surface. In practice, this may be approximated by an average of the illuminance at a representative number of points on the surface. The number and position of these points should be as specified in the CIE Publication No. 140-2000.

Average Luminance (over a surface) (Lav) – Luminance averaged over the specified surface. In practice, this may be approximated by an average of the luminance of a representative number of points of the surface. The number and position of these points should be as specified in the CIE Publication No. 140-2000. The Average Luminances are calculated for the entire carriageway seen from an observation point placed in the centre of each lane in turn and are the arithmetic mean of the luminances obtained at the calculation points.

Bonding Jumper - A reliable conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

Bracket – A component used to support a luminaire at a definite distance from the axis of the lower straight portion of a column of single or double form and demountable from the column.

Bracket Projection – Horizontal distance from the point of entry of the bracket to the luminaire to a vertical line passing through the center of the cross-section of the column at ground level.

Breakaway Transformer Base – A cast aluminium breakaway base for lighting columns meeting the requirements of AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

Candela, cd – The International System (SI) unit of Luminous intensity in a specified direction.

Candela per square meter, cd/m²- The SI unit of luminance.

Clamp - A gripping device for connection of conductors for cable jointing.

Coefficient of Utilisation, CU – The ratio of the luminous flux (lumens) from a luminaire upon a surface (roadway, etc.) to the lumens emitted by the luminaire lamp alone.

Control Cabinet – An enclosure designed for mounting on concrete foundation and provided with a frame in which swinging doors are hung and where circuit protective devices and controls for motorway/expressway lighting systems are installed.

Employer- As defined in the General Conditions of Contract

Engineer- As defined in the General Conditions of Contract

Energy Saving: Practice of decreasing the quantity of energy used.

Feeder Pillar – As Control Cabinet but for local roads lighting systems

Flange Plate – A plate with an opening for cable entry welded to a column which is surface mounted to allow it to be secured to a concrete foundation or to other structures.

Floodlight – Projector designed for floodlighting, usually capable of being pointed in any direction.

Frame – A frame is an assembly consisting of all parts of the circuit breaker except the trip unit and the terminal connectors.

Glare – The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort or loss of visual performance and visibility.

High Pressure Sodium Lamp – An electric discharge lamp in which light is produced by the excitation of metallic vapors and inert gases (chiefly sodium, Mercury and Xenon) at a pressure of approximately one atmosphere.

Interrupting Current – The rated interruption current is the maximum current at rated voltage which a device is required to interrupt under the specified conditions and with a normal frequency recovery voltage not less than a rated voltage.

IP - Index of Protection

Isocandela Line – A line plotted on any appropriate co-ordinates to show directions in space, about a source of light , in which the candlepower is the same. For a complete exploration the line always is a closed curve. A series of such curves usually of equal increments of candle-power is called an isocandela diagram.

Isolux Line – A line plotted on any appropriate co-ordinates to show points on a surface where the illumination is the same. For a complete exploration the line is always a closed curve. A series of such curves, usually of equal increments of illumination, is called an isolux diagram.

Lighting Unit – The assembly of lighting column, bracket and luminaire.

Lowering Device – A device used to lower a high mast luminaires carriage to a convenient distance above ground level (1.0 m maximum) for ease of inspection and maintenance.

Lumen, Lm – The unit of luminous flux. It is equal to the flux through a unit solid angle (steradian) from a uniform point source of one candela or to the flux on a unit surface all points of which are at unit distance from a uniform point source of one candela.

Luminaire – Apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except for the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries with the means for connecting them to the electric supply.

Luminaire Array – A set of luminaires arranged in an effective light distribution source at the top of a column.

Luminance (photometric brightness) – Luminance in a direction, at a point on the surface of a source or of any other real or virtual surface is the quotient of the luminous flux leaving or passing through an element of the surface surrounding the point and propagated in directions defined by an elementary cone containing the given direction , by the product of the solid angle of the cone and the area of the orthogonal projection of the element of the surface on a plane perpendicular to the given direction; or it is the luminous intensity of any surface in a given direction per unit of projected area of the surface as viewed for that direction.

Luminance Uniformity – The overall luminance uniformity is defined as the ratio:

L min /L ave.

In the determination of this value , “L min” is the minimum local luminance and “L ave” the average luminance of the whole carriageway, both seen from an observation point placed in the centre of each lane in turn.

The longitudinal uniformity is considered for each driving lane and is the ratio:

L min /L max.

along the center line of each lane assuming that the observation point is placed on the center-line.The operative values of average luminance, overall luminance uniformity and longitudinal uniformity are the lowest values in each case.

Lux, Lx – The (SI) unit of illumination. It is the illumination of a surface one square meter in area on which there is a uniformly distributed flux of one lumen or the illumination produced on a surface all points of which are at a distance of one meter from a uniform point source of one candela.

MCB/MCCB – Miniature circuit breaker/Moulded case circuit breaker.

Maintained – in-service diminished value (of luminance or illuminance) by a maintenance factor

Maintenance Factor (MF) – Ratio of the average (il)luminance on or of the specified surface after a certain period of use of the lighting installation to the average (il)luminance obtained under the same conditions for the installation considered conventionally as new.

Metal Halide Lamp – A discharge lamp in which the light is produced by the radiation from a mixture of metallic vapour (for example, mercury) and the products of the dissociation of halides (halides of thallium, indium, or sodium).

MEW – Ministry of Electricity and Water

MOC – Ministry of Communications

Mounting Height – The vertical distance between the road surface and the center of the apparent light source of the luminaire.

PVC-Polyvynil Chloride

Spacing - For road lighting the distance between successive lighting units, measured along the centerline of the road.

Symmetrical Current – A symmetrical current is an alternating current that is balanced around the zero current axis, the positive and negative peaks being equal but opposite in sign. This is always the condition during normal current flow.

TI – **Threshold Increment (TI)** – Measure of disability glare expressed as the percentage increase in contrast required between an object and its background for it to be seen equally well with a source of glare present. Higher values of **T**I correspond to greater disability glare.

UL - Underwriter’s Laboratories

uPVC – Unplasticized Polyvynil Chloride

Vertical or Brightness Control - The brightness control classification provides a means of rating the luminaires according to the amount of glare or brightness at high angles from the luminaire. The major categories are: cut-off, semi-cut-off and non-cut-off.

1401.03 MATERIALS AND WORKMANSHIP

1401.03.1 Materials

All materials and equipment shall comply as a minimum with:

a. The latest relevant recommendations of the International Electrotechnical Commission (IEC) if available.

b. The latest relevant British Standard Specifications (BS), or ASTM or AASHTO standards, if IEC standards are not applicable or not available as such.

This applies to quality of material, manufacture and testing. If standards as mentioned above conflict with these Specifications, then the requirements of these Specifications shall apply.

Contractors who wish to base their submittals on standards other than those standards mentioned under items a. and b. herein above, may do so provided they confirm that such standards meet the requirements of the said items, as a minimum. In due time the Contractor will be requested to prove this and, as necessary, this shall be verified by the MEW/Engineer or appointed Employer's Representative.

Paragraphs a. and b. above shall apply wherever BS, ASTM or AASHTO are referred to in the various Clauses of these Specifications.

All materials used shall be new and the best of their respective kind and the most suitable for working under the weather and site conditions set out in these Specifications, thus withstanding the variations of temperature and other prevailing conditions without distortion or deterioration of any adjacent part.

The equipment included in these Specifications shall be so manufactured as to facilitate easy and proper erection and maintenance. The design of all equipment shall ensure satisfactory operation under the site conditions mentioned.

All terminal blocks for cable terminations shall be of the high temperature type, i.e. suitable for use at a minimum operating temperature of 90˚C, and in the case of cut-out box assemblies they shall be of the polycarbonate type.

The manufacturer selected by the Contractor shall be on the approved list of manufacturers for the supply of street lighting and associated equipment to the Ministry of Electricity and Water.

The Contractor shall be responsible for the safe storage of all materials furnished to or by him until it has been incorporated in the completed project and finally accepted by the MEW/Engineer/Employer. Any materials lost, stolen, damaged or found to be defective shall be replaced by the Contractor at his own expense and no extension of time shall be granted in respect of any time taken to obtain replacement materials.

1401.03.2 Workmanship

The Workmanship of all parts shall be of the highest order and defective parts shall not be welded, plugged or filled in without the written permission of the MEW/Engineer. Metal works shall be adequately protected against corrosion and oxidation, bearing in mind the site conditions mentioned below.. Corresponding parts shall be made to gauge and shall be interchangeable wherever possible throughout the Contract Works, and the Contractor shall prove interchangeability as and when requested by the MEW/Engineer. All nuts, screws and bolts which will be required to be removed and replaced for maintenance operations shall be of the captive type.

1401.04 SUBCONTRACTING REQUIREMENTS

1401.04.1 Electrical Subcontractor

All lighting and electrical works shall be carried out by a sub-contractor who is on the Ministry of Electricity and Water's approved list of electrical contractors with good previous experience in street lighting and electrical works.

The Contractor shall submit the name of the subcontractor(s) he proposes to use for lighting and electrical works to the MEW/Engineer for approval. The Contractor will not be allowed to carry out this work, unless he is on MEW's list of approved electrical contractors for this type of work.

All lighting and electrical work is considered to be of a speciality nature and shall be subcontracted without charge against any subcontracting limitation provision that may be included in the Conditions of Particular Application of the Contract Documents.

The staff employed by the electrical subcontractor must be approved by the Ministry of Electricity and Water.

The Electrical sub-contractor must have an electrical engineer and an electrical supervisor for ensuring proper supervision of the work. The electrical engineer shall have a degree of Bachelor of Science (B.Sc.) in Electrical Engineering and shall possess a minimum five (5) years of practical experience in total out of which two (2) years must be acquired in the field of motorway and expressway lighting works. The electrical supervisor shall have a 3-years Polytechnical Diploma in Electrical Engineering and minimum Eight (8) years practical experience in the field of street lighting works. All Technicians shall be High School graduates and shall have minimum five (5) years experience in the related field.

The electrical engineer and the electrical supervisor shall be available at site at all hours during the working days. The Electrical sub-contractor shall obtain approval of all his staff before starting any work at site.

1401.04.2 Work Programme

The Contractor shall submit detailed work programme for approval by the MEW/ Engineer. Subsequently, updated work schedules in triplicate shall be submitted to the MEW/Engineer monthly, with the percentage of work completion marked on the same.

1401.04.3 Working Drawings

The Contractor shall submit for approval of the MEW /Engineer, detailed working drawings. Working drawings shall be prepared with AutoCAD to Scale 1:1000, 1:2000 or as directed by the MEW/Engineer in A-1 size only and submitted in two (2) copies minimum. The Contractor shall incorporate into the working drawings cable duct and handhole layouts for the entire street lighting systems with all necessary details. The Contractor shall also prepare and submit for MEW's/Engineer's approval all necessary schematics (single line diagrams), electrical load schedules, etc. for street lighting and other electrical systems being executed under the Contract.

Works at site must not be started until and unless approval is gained for all the working drawings and details from the MEW /Engineer.

The Contractor shall submit to MEW/Engineer in AutoCAD 2007 format (or in the format as asked by the MEW/Engineer) three (3) complete sets all working drawings copied on compact discs (CD's). The Contractor shall also submit PDF copies of all approved working drawings copied on three (3) sets of compact discs.

1401.04.4 As-Built Drawings

As-built drawings shall be prepared with AutoCAD to the same scale as the working drawings and submitted in One (1) set of mother-prints of diaze polyester films and two (2) sets of paper prints. The Contractor shall also submit the drawings in four (4) sets of Compact Discs.

The Contractor should maintain a continuous record of all the field deviations from the working drawings, if any, as approved by the MEW/Engineer and shall incorporate these into the as-built drawings. The locations of all handholes, road crossing ducts, routing of cables/cable ducts, their distances from the kerbsides as well as feeding details of the control cabinets/feeder pillars, like Sub-station No., Low voltage feeder, etc. shall be all clearly indicated on the drawings. The drawings of all major items of equipment shall also be provided together with a schedule detailing make, type, rating etc. of all the equipment and components therein. The Contractor shall also provide as-built drawings to scale 1 :2000 when asked by the MEW/ Engineer.

1401.04.5 Micro-Film

The Contractor has to supply the Ministry of Electricity and Water, with three (3) sets of 35 mm. Silver Halide micro-film aperture cards made from (as fitted or built) original drawings. The front face of these aperture cards should be left blank and on the reverse face, details like Contractor's /Electrical sub-contractor's Name, Contract No., Project and drawing titles, drawing No., reduction ratio and date shall be printed or typed directly on the cards. Two samples of processed micro-film aperture cards shall be submitted to the MEW for approval prior to final submission.

1401.04.6 Inventory Information On Compact Disc (CD)

The Contractor shall prepare a complete and fully detailed inventory of each and every item of street lighting equipment, accessories etc. employed in the lighting installation of the project and provide the complete information on compact discs (CDs) in four (4) complete sets.

1401.04.7 Services Co-Ordination

The Contractor shall notify in all cases and obtain necessary clearances from other Ministries and Authorities in case their services might be affected by the electrical works. The Contractor shall refer to all relevant Civil, Sewage, Drainage, Telephone, EHV/HV/LV Cable routes and all other services drawings and obtain for himself the exact locations and position of various services, so that in the execution of the electrical work, he will not disturb or damage any other services and additionally shall maintain adequate and specified clearances between street and external lighting and all other services.

The Contractor shall also refer to and comply with the current regulations and specifications of Ministries, Authorities and Companies before commencing in any works adjacent to equipment, plant, cables etc.belonging to them.

The above requirement will not relieve the Contractor of his responsibility for taking every precaution to avoid damage to equipment, plant, cables etc. and he will be held responsible for the cost of repair of all damages.

1401.04.8 Safety Regulations

The Contractor shall strictly abide by all safety rules and regulations issued by the different Ministries and Authorities like, Ministry of Electricity & Water, Ministry of Public Works, Ministry of Communication, Ministry of Interior, Kuwait Municipality and others, and shall provide in all cases picket fences, warning tapes, warning lights, danger signs and watchmen to ensure that no mishaps befall the public or properties. During hours of darkness an adequate number of danger signs shall be provided.

1401.05 SERVICE CONNECTION

This work shall consist of obtaining service connection to the control cabinets/feeder pillars location indicated on the Drawings.

The Contractor shall be responsible for making the necessary arrangements with the Electrical Distribution Network Department of the Ministry of Electricity and Water for the connection of the control cabinets/feeder pillars of the Lighting Systems to the power supply network. A formal application for such connection must be made to Ministry of Electricity and Water through the Engineer. Adequate notice shall be given to the Engineer to permit the processing of this application. Connection to the network will be carried out by MEW. Neither connection charges nor street lighting power supply charges will be made to the Contractor.

The power supply to the control cabinets/feeder pillars will be 3-phase 415/240 V, 4-wire, 50 Hz, solidly grounded at the neutral point.

All regulations of the Ministry of Electricity and Water shall be strictly observed in the distribution and use of the supply. Under no circumstance shall any installation be connected to the mains supply until authorized by the MEW/Engineer.

The Ministry of Electricity and Water will provide the power supply to the control cabinets/feeder pillars.

It shall be the Contractor’s responsibility to ensure phase balancing throughout the system before connection to the Ministry of Electricity and Water network.

1401.06 SITE CONDITIONS

Climatic conditions in Kuwait are rigorous during summer and the ambient shade temperature can rise to 55˚C, with a drop to -6˚C during the night in the winter. The sun temperature can reach 84˚C as measured with a black bulb thermometer. Periods of high humidity are common and a relative humidity of 100% at 30˚C has been recorded. Violent sand and dust storms occur with wind speeds in excess of 100 km/h and even on comparatively still days, fine dust is carried in suspension in the atmosphere. The average rainfall is in the order of 150 mm/annum, but this may be concentrated into two or three severe downpours. The equipment and materials required under these Specifications shall give continuous and trouble-free service under the arduous conditions mentioned herein.

The cables will be laid partly in ducts or concrete trenches or trays and partly buried in the ground at a depth of 750 mm where the soil varies from sandy to rock-like gatch (comparable to dry hard clay), with a corresponding

ground thermal resisitivity “g” of 120˚C cm/watt and a ground temperature varying from +35˚C in summer to +15˚C in winter.

The cables called for in these Specifications shall give trouble-free service under the worst conditions encountered in Kuwait and shall carry their rated currents continuously under the worst temperature conditions which prevails in summer and shall also withstand maximum fault currents without damage or deterioration.

The cable drum may require to be stored for periods up to 18 months in the open and be exposed to direct sunlight. Therefore, the cables shall be so designed as to withstand these conditions without deterioration of their mechanical and electrical properties.

The soil in Kuwait is very corrosive. Sulphate-reducing bacteria are common to all soils in the Kuwait area, and as the soil is generally rich in sulphate, the anaerobic conditions which may arise in contact with buried pipes and cables, favours the development of these anaerobic organisms which generate hydrogen sulphide and render these areas most corrosive.

In view of the high temperature encountered in Kuwait, it should be stressed that PVC plasticizers should be of the long chain high molecular weight type to reduce the loss of plasticizer in the hot conditions. This prevents shrinkage of the PVC with subsequent cracking of the film.

A typical analysis of a soil sample is as follows:

Appearance	:	Wet coarse sand, with some clay
pH value of water in contact with the sand	:	10.0
Calcium carbonate as $CaCO_3$	:	40.00% dry basis
Calcium sulphate as $CaSO_4$	:	25.000% dry basis
Silica as $Si0_2$	:	22.00% dry basis
Magnesium sulphate as $MgSO_4$	:	6.00% dry basis
Sodium Chloride as NaC1	:	5.00% dry basis
Iron as Fe_2O_3	:	2.00% dry basis
Sulphate – reducing Bacteria	:	Present
Moisture	:	15.00%

It should be noted that the sand is not corrosive under dry aerated conditions, but under anaerobic conditions the sulphate-reducing bacteria in the sand will result in serious corrosion of metals in contact with the sand. The PVC shall be suitable for the above soil conditions and the Contractor shall confirm in his submission that the PVC will be suitable for these conditions.

All equipment supplied under this Contract shall be suitably derated to carry the full load circuit currents under the temperature and environmental conditions applicable to their location in the Works.

1401.07 EXISTING UTILITIES AND STORM SEWERS

The Contractor shall make his own investigations to determine the existence, nature and location of all utility lines, cables, conduits, ducts, pipes, storm sewers etc. and appurtenances thereto within the limits of the Work. The Contractor shall be held responsible for any damage of all such existing features and appurtenances resulting from the operations of his equipment or men.

The Contractor shall, at his own expense, restore such damaged features or appurtenance to a condition equal to that existing before such damage was done, by repairing, rebuilding or replacing it as directed by the MEW/ Engineer.

No extra compensation will be allowed to the Contractor for any expenses incurred because of delays, inconvenience or interruptions to his work resulting from compliance with the above requirements.

1401.08 EXAMINATION OF THE SITE

The Contractor shall examine the site of the work in accordance with the Conditions of Contract to determine all Work included under this Contract and all conditions to be encountered in performing the Work under this Contract.

The Contractor, prior to the commencement of his work shall notify the Ministry of Communications (MOC) and the Ministry of Electricity and Water (MEW) of his intent to perform this work. Upon request from the Contractor, the concerned Ministry will locate or require the Contractor to locate , any buried cable, conduit or other electrical and telephone facilities which may interfere with the Contractor's operations. This shall in no way relieve the Contractor of his responsibility for the repair or replacement of facilities damaged by his operations. The Contractor shall report any known or suspected damage to any electrical and telephone facilities immediately to the MEW/MOC/Engineer.

In the event of damage to any MEW or MOC or other facilities through the Contractor's operations, the MEW or the MOC will require the Contractor to restore the system to operation immediately. The repair or replacement of damaged equipment shall meet with the approval of the MEW/MOC/ Engineer.

All damaged cables shall be replaced in complete lengths and all joints shall be in locations permitted in the original installation. No extra compensation shall be allowed to the Contractor for compliance with these requirements or for any expenses incurred to effect repairs to damaged electrical or telephone or other facilities.

1401.09 CONTROL OF APPROVAL OF MATERIALS

These Specifications govern the procedures for documentation and approval of all materials and equipment proposed for the lighting and electrical works in this Contract. All materials must be obtained from the Ministry of Electricity and Water's approved list of manufacturers and must be approved by the MEW.

The Contractor shall conduct his own search into the timely availability of the specified equipment and materials and shall ensure that all equipment and materials are in strict accordance with these Specifications.

All cost of work and material, including samples, required for satisfying these Specifications shall be included in the rates given in the Bills of Quantities and no additional compensation shall be allowed to the Contractor for any incidental costs that may occur in fulfilling the requirements of these Specifications.

All the required items as specified herein for each of the various submission stages shall be compiled by the Contractor and submitted to the MEW/Engineer at one time. A letter enumerating the submitted items shall accompany the submittal package. Partial or sporadic submittals will be unacceptable and the MEW/Engineer will return such incomplete submittals unmarked except that under justifiable and extenuating circumstances the Contractor shall seek the MEW's/Engineer's permission to make partial submittal pending receipt of additional information. The MEW/Engineer will evaluate the circumstances and possible consequences and may accept to review such partial submittals conditionally.

All the required drawings, technical data and design computations, together with the duly completed Submittal Schedules required by the Contract Documents, shall be presented in an academic and professional manner in the English language only.

Formulae and substituted numerical values shall be clearly shown. Computer print-outs for the computations will be acceptable.

Approval of materials and equipment shall be processed as follows:

A. Approval Stage A – Source Approval

Within 120 days of the starting date (Date of Enterprise) the Contractor shall submit for the approval of the MEW/Engineer the name of the manufacturer, the catalogue reference number and full manufacturer's technical literature for each major item of equipment to be supplied for the lighting and electrical works in this Contract. The items of equipment shall include, but not be limited to:

Lighting Masts
Lighting columns
Luminaires

Lamps
Control Gears
Cut-outs
Control Cabinets / Feeder Pillars
Cables & Joints
Miniature Circuit Breakers (MCB's)
Moulded Case Circuit Breakers (MCCB's)
Safety Switches
Breakaway Transformer Bases
Electrical Breakaway Quick Disconnects

Where items of equipment submitted by the Contractor are not approved by the MEW/Engineer, the Contractor shall submit details of alternative equipment if necessary supplied by different manufacturers, until the MEW's/Engineer's approval is obtained.

B. Approval Stage B – Material Approval

Subsequent to the Source Approval under Stage A and at least 6 months before the Contractor requires to place orders for any materials and/or equipment he shall submit the following for the approval of the MEW/Engineer (such approval being subject to satisfactory site performance and operations):

i. General Requirements

A complete list of equipment and materials that are proposed for use together with the manufacturers names and catalogue reference numbers and anticipated delivery dates.

The list shall include descriptive literature and technical details and drawings sufficient to fully describe and explain the proposed lighting and electrical system.

ii. Letter of Capacity

Satisfactory evidence that the manufacturers whose products are being submitted have previously supplied various clients with lighting units and luminaires similar to those in the Contract Documents. Evidence of each manufacturer's production capability shall also be provided. Submissions which do not include such evidence or which include unsatisfactory evidence may be rejected.

iii. Submittal Schedules

Fully completed signed copies of all Submittal Schedules required by the Contract Documents including:

a. Construction Particulars for Lighting High Masts

b. Construction Particulars for Lighting Columns

c. Chemical Composition and Mechanical Properties of Steel for Lighting High Masts.

d. Chemical Composition and Mechanical Properties of Steel for Lighting Columns.

e. Deviations from the Technical Specification for Lighting High Masts.

f. Deviations from the Technical Specifications for Lighting Columns.

g. Technical Schedules and Guaranteed Particulars for High Mast Lighting Unit

h. Technical Schedules and Guaranteed Particulars for Conventional Lighting Units.

i. Technical Schedules and Guaranteed Particulars for Luminaires .

j. Illumination Levels for Luminance (cd/m2) Values by Computerized Methods as Per CIE-140-2000

k. Illumination Levels for Horizontal Illuminance (Lux) Value by Computerized Method and 9-Point Schedules

l. Luminance- Plots

m. Tehnical Schedules and Guaranteed Particulars for Lamps.

n. Technical Schedules and Guaranteed Particulars for Ballasts, Capacitors and Ignitors.

o. Technical Schedule and Guaranteed Particulars for Undercrossing Luminaires.

p. Illumination Level – Guaranteed Particulars for Undercrossing Luminaires.

q. Technical Schedule and Guaranteed Particulars for Gantry and Bridge Mounted Sign Lighting Fixtures and Floodlights.

r. Technical Schedules and Guaranteed Particulars for Control Cabinets/Feeder Pillars.

iv. Electric Cables

a. Dimensioned drawings showing the details (including a cross-section) of each and every size of cable annotated to show the make-up of the cables.

b. Short circuit current curves in accordance with Clause 1404.08.7 of these Specifications.

c. Guarantee certificate(s) in accordance with Clause 1404.08.8 of these Specifications.

d. Independent laboratory test certificates and reports for each type of cable.

e. Voltage Drop Calculations.

v. Lighting High Masts (Height greater than 22 m)

For each mast height:

a. General dimensions of all component parts.

b. The total maximum moments, the section modulus required and the section modulus furnished at the base of the mast, at the door opening, at all splices, at the connection of the ring and at least every 6.0 m along the mast.

c. Computation of stresses in the flange plate and anchor bolts, and at the door opening in the mast.

d. Maximum deflection at the top of the mast under load conditions and gust wind velocity (V10) of 160 km/h blowing in the most unfavourable direction at a height of 10 meters above ground and a mean hourly wind velocity of 115 km/h.

All above calculations shall be for masts equipped with the luminaires and control gears proposed by the Contractor and approved by the MEW/Engineer.

vi. Conventional Lighting Columns (Height 22 m and less)

For each column height and/or mounting configuration:

a. General dimensions of all component parts, including breakaway transformer bases where required.

b. The total maximum moments, the section modulus required and the section modulus furnished at the base of the column and at the door openings.

c. Computation of stresses in the flange plate, connection attachment and anchor bolts, and at the door opening in the column.

Additionally for hinged columns only:

d. Full details of the construction and method of operation.

e. Working drawings of the proposed hinge mechanism.

All above calculations shall be for columns equipped with the luminaires and controlgears proposed by the Contractor and approved for the project, and mounted on breakaway transformer bases (16 m height or less) where required.

vii. Performance Standards

To allow an assessment of the most suitable and efficient lighting unit to be made the Contractor shall submit a table of the number of lighting units required for each separate lighting system (i.e. every luminaire/mounting height combination) to illuminate one kilometer of straight motorway or roadway to the standards given in Clause 1412 of these Specifications for the relevant Roadway Designation.

viii. Manufacturer's Literature and Technical Data

Complete manufacturer's specifications and detailed technical literature, dimensioned drawings, data, etc., of the masts, columns, breakaway transformer bases, raising and lowering systems for high mast units, luminaires, lamps, control gears (chokes, capacitors, ignitors), wire, cables, cable joints, conduits, trunking ducts, junction boxes, cut-outs, circuit-breakers, switchgear, electrical breakaway quick disconnects, photoelectric and time-switch controls, control cabinet/feeder pillar equipment, and all other equipment for the Works under these Specifications. Manufacturer's catalogue number of adhesives, tape and miscellaneous items shall be listed.

All dimensional drawings for major items of equipment shall be submitted in A1 size only and manufacturer's name, reference number, drawing number, revisions, date, project title, Contract number, MEW/Employer and all other relevant information shall be included.

ix. Shop Drawings

Shop drawings shall be provided for lighting masts and columns including shafts and arms, showing in detail the fabrication thereof and the description of any materials used in the fabrication, breakaway transformer bases, anchor bolts and foundation reinforcing materials. Shop drawings shall also be provided for the fabrication of the control cabinets/feeder pillars, the parts thereof and the wiring of the equipment therein.

Scaled drawings shall also be provided to show the exact positions and wiring of the control gear and electrical breakaway quick disconnects within the column base compartments.

All shop drawings shall be submitted in A1 size with details / particulars as mentioned in item viii above.

x. Photometric Data

Isolux diagrams of horizontal illumination, utilisation curves, and isocandela diagrams for the proposed luminaires. When requested by the MEW/Engineer the Contractor shall also furnish intensity tables for all vertical and lateral angles of the luminaires.

xi. Performance Calculations

Performance Calculation in the form of computer print-outs applied by international software and electronic CD's as recommended by CIE Publication No. 115-1995 and CIE 140:2000, for average road surface luminance, overall and longitudinal luminance uniformity ratios, glare control marks, TI, and average illuminance values and uniformities , at typical sections of the main lines and of ramps at interchanges. Separate calculations are to be submitted for each lighting system offered, i.e. every different combination of mounting height/luminaire type/ road geometry/column and mast spacing/luminaire and/or reflector angle etc. Such calculations shall include for underbridge lighting systems. Performance calculations shall also be provided for gantry and bridge mounted sign lighting systems.

Due account shall be taken of the effective mounting height and horizontal displacement of the luminaires with respect to the carriageway(s) to be illuminated.

A maintenance factor of 0.75 shall be taken into consideration for all of the above performance calculations.

xii. Lamps, Lamp Life, Lumens Maintenance Curves and Spectral Distribution

The Contractor shall submit manufacturer's graphs of the guaranteed lamp life to burn-out for constant supply voltage between 240 volts and 260 volts for each type of lamp proposed.

In addition, lumen maintenance curves given as the percentage of the initial lumens to the percentage of rated lamp life, lamp survival curves and also the spectral distribution of each type of lamp shall be submitted.

xiii. Luminaire Adjustments

Complete information on the recommended aiming and adjustment of each and every luminaire and optional system to achieve optimum lighting performance.

xiv. Independent Certification for Luminaires

Independent test certifications certifying that the luminaires performance accords with the details submitted by the Contractor and certifying that the luminaires sealing qualities (against ingress of dust and moisture) and bowl heat resistance meet the requirements of the Specifications.

xv. Independent Certification for Breakaway Transformer Bases

Independent test certificates, certifying that the breakaway transformer bases, when tested complete with each proposed type of lighting column, meet the requirements of AASHTO Standard Specification for Structural Support for Highway Signs, Luminaires and Traffic Signals.

C. Approval Stage C – Samples

The Contractor shall provide the following material and equipment samples:

i.. Sample length of lighting mast in accordance with Clause 1407.01
ii. Sample length of lighting column in accordance with Clause 1408.01
iii. Sample length of lighting column in accordance with Clause 1409.01
iv. Breakaway transformer base
v. Electrical breakaway quick disconnect
vi Each type of luminaire proposed for use (including under crossing luminaires, luminaires for guide signs and for signs mounted on support structures)
vii. Each type of lamp
viii. Each type of cut-out
ix. Each type of control gear panel
x. Safety switches.
xi. Street lighting control cabinets/ feeder pillars
xii. 25cm. length from each type of cable proposed for the works all fixed on a wooden board and properly labeled for identification.
xiii. Joint kit
xiv. Earth rod
xv. Handholes and manholes
xvi. 25 cm. length from each type of uPVC duct and conduit, all fixed on a wooden board and properly labeled.
xvii. All forms of reinforcing steel for concrete work

The Contractor may be required to submit samples of any other materials for approval and to carry out any test if so required and asked by MEW/Engineer. The MEW/Engineer shall retain all samples which are approved to be used as reference standards for overall quality, materials, workmanship and finish of the equipment supplied under the Contract. The samples are non-returnable.

All samples shall be provided with non-removable printed water-proof labels giving material description and other Contract information such as project title, Contract number etc.

Any Equipment which, in the opinion of the MEW/Engineer, does not correspond to the samples in overall quality, materials, workmanship or finish is liable to be rejected.

D. Approval Stage D – Guarantees, Testing and Inspection

Only after the requirements of Stages B and C herein have been completely satisfied and the MEW's/Engineer's written approval gained, and before any electrical equipment including luminaires, lamps, switchgear, control gear, cables, joints, electrical quick disconnects, control cabinets/feeder pillars, masts, columns and breakaway transformer bases are delivered to the job site the following requirements shall be met:

i. The Contractor shall obtain and forward to the MEW/Engineer written certified and notarized statements from the manufacturers guaranteeing that the major items of equipment and /or materials, after manufacture, comply in all respects with the requirements of these Specifications except for non-complaint variations which have been accepted by the MEW/Engineer. In particular any site performance guarantees required by the relevant standard called for in the material specification shall be provided. The guarantee certificates shall be signed and stamped by the manufacturer's reprsentative, their local agent and the Electrical subcontractor.

   The major items of equipment shall be notified to the Contractor by the MEW/Engineer and shall include but not be limited to: masts, columns, breakaway transformer bases, luminaires , lamps, cables, control gear equipment and electrical quick disconnects.

ii. Where specific testing is required by the Specifications or where tests have been instructed by the MEW/Engineer, such tests shall be performed in strict adherence to the specified testing procedures.

iii. The Contractor shall prepare the equipment in his shop so that it can be readily inspected if an Inspector request an inspection of the equipment. The shop must be a location within the area of the Site. The Inspector will tag the equipment which is inspected and approved, and it may then be delivered to the job site. Material that has not been approved shall not be paid for, nor shall it be delivered to the job Site or installed in the Works. A one-week notice will be required for the material inspection.

E. Unacceptable Equipment and Materials

The Contractor shall clearly understand that equipment and materials which have been installed prior to fully satisfying the requirements of these Specifications will be subject to removal, and possible disposal, at the Contractor's expense.

F. Engineering Assistance

The Contractor shall obtain from the light mast and luminaire manufacturer engineering assistance for the assembly and erection of high mast lighting installations, luminaires and ballasts, power cable, supporting cables to the ring, head frame assembly and all other equipment to make the lighting unit operational. Such assistance shall include experienced personnel to supervise the assembly and erection of the complete installation. The Contractor's proposals for such assistance including the names and experience records of the manufacturer's personnel shall be submitted to the MEW/Engineer for approval. The cost of all engineering assistance shall be borne by the Contractor.

1401.10 INSPECTION AND TESTING

The equipment covered by these Specifications will be subject to inspection during manufacture and shall include for but not limited to major items of equipment such as masts, columns, luminaires, control gear, control cabinets/feeder pillars etc. The Contractor shall appoint a Third Party Inspector who is on the Ministry of Electricity and Water's approved list of Third Party Inspectors and shall bear all costs for inspection works including the Inspector's charges. The Contractor shall provide all necessary facilities for the Inspector who may carry out or witness any tests that may be deemed necessary including representation, travelling, and transportation for factory tests. All required materials for the inspection and testing as well as all testing equipment shall be supplied by the Contractor and included in the Contract price. The Contractor shall carry out all tests specified in the latest relevant CIE/IEC/BSS/ASTM/AASHTO and BS EN 12767 level 4 specifications These shall be carried out to the satisfaction of and in the presence of the Inspector. If so asked by the MEW/Engineer, the Inspector appointed by the Contractor shall also witness luminance and illumination tests on mock-up lighting systems to ensure that the levels of luminance, illumination, uniformity ratios and other data guaranteed at the time of submission are actually obtainable. These tests shall be carried out prior to the shipment of the luminaires and other equipment or materials. The Contractor shall give due notice of not less than fourteen days to the MEW/ Engineer as to when the different parts of the equipment will be ready for the different tests involved.The Contractor shall make all arrangements with the Ministry of Public Works for

carrying out the necessary tests on the concrete in their laboratory at his own cost. He shall follow the MEW's/Engineer's instructions in this regard and carry out such tests at MEW's/Engineer's entire satisfaction.

Shipment of materials and equipment shall not be effected unless the Inspector's release note is obtained. No release note issued by the Inspector shall relieve the Contractor from his liability to supply equipment or exonerate him from any of his guarantees according to these Specifications and the accepted submittals.

All joints, taps and ground connections shall be inspected by the MEW/Engineer before the wires and cables are permanently trained in handholes, junction boxes, conduit, or light columns.

After the installation has been completed, the Contractor shall perform and tabulate measurements of current, voltage and insulation resistance readings for each lighting circuit of all control cabinets/feeder pillars. Any indications of ground fault which are a result of work performed by the Contractor shall be thoroughly investigated and remedied before final acceptance of the installation. Insulation resistance readings shall meet the approval of the MEW/ Engineer. Lamp terminal voltages shall be taken at the locations designated by the MEW/Engineer . The Contractor shall also carry out field performance tests at the locations as asked by the MEW/Engineer.

The Inspector appointed by the Contractor shall witness all the voltage, current and insulation measurements and the field performance tests as specified in Clause 1401.11 of these Specifications. The field performance tests will also be witnessed by the representatives of the Ministry of Electricity and Water.

The Inspector in all cases shall compile the test/measurement results and readings in the English language only and submit same to the Ministry of Electricity and Water in two(2) complete sets of hard and soft copies for scrutiny and record purposes.

1401.11 FIELD PERFORMANCE TESTS

Prior to completion of the Work, all electrical circuits and lighting systems shall be checked by the Contractor to the satisfaction of the MEW/Engineer. Each circuit shall be tested for continuity and for ground. A megohmeter test shall be made on each circuit between the circuit conductor and a ground. The insulation resistance shall not be less than ten megaohms at a test level of 1000 volts and the readings shall be recorded and furnished to the MEW/Engineer.

Measurements of illumination shall be made at the positions determined in accordance with the recommendations of the CIE Publication No. 140-2000 titled " Calculations and Measurements of Luminance and Illuminance in Road Lighting". The locations for measurement of illumination and for measurement of luminance along each section of motorway or roadway shall be selected by the MEW/Engineer, and each location shall be considered as an individual performance test to be assessed against the performance standards specified in Clause 1412 herein. The Contractor shall provide all necessary equipment (including all electrical and illumination test meters) and shall measure and record values of luminance and illuminance at all predetermined positions. These measurements shall be witnessed by an inspector appointed by the Contractor, who may require demonstration of the accuracy and reliability of any instruments used. Calibration Certification for all measuring equipment shall be presented to the MEW/Engineer for approval before any field tests are undertaken.

A functional test shall be made to verify that every part of the system functions as required by the Drawings and these Specifications. The length of the functional test shall consist of not less than five nights of continuous satisfactory operation. If unsatisfactory performance of the system develops due to faulty material, fabrication or installation, the condition shall be corrected and the test repeated until five nights of continuous satisfactory performance is achieved. Any components of the lighting system found to be faulty, malfunctioning or damaged during the test period shall be removed and replaced at the Contractor's expense.

During the five nights test period, the Contractor's maintenance crews shall maintain the system or systems undergoing test. The costs of any maintenance necessary except electrical energy and maintenance due to damage by public traffic shall be at the Contractor's expense and no additional compensation shall be allowed. The functional test for each road lighting system shall consist of an operational test for five consecutive nights according to other regular lighting schedule shut-down caused by factors beyond the Contractor's control shall not constitute discontinuity of the functional test.

The Contractor shall provide hand tools and test equipment for the use of the MEW/Engineer.

1401.12 MINISTRY OF ELECTRICITY AND WATER SYSTEM

System values shall be as follows:

a. For roadway lighting:
240/415 volts, +/- 6%, 3-phase, 4 wire, 50Hz.
Maximum fault level: 31 MVA for 0.5 seconds
Note – System has a solidly earthed neutral.

b. Secondary Distribution:
11kV, 3 –Phase, 3-wire, 50 Hz
Maximum fault level of 350 MVA for 3 seconds.

1401.13 REMOVAL AND RESITING OF EXISTING LIGHTING UNITS

1401.13.1 General

The Ministry of Electricity and Water will be responsible for the disconnection of the power supply to existing lighting units which are redundant or which are to be resited under this Contract.

1401.13.2 Removal of Redundant Lighting Units and Control Cabinets/Feeder Pillars

Existing lighting columns, brackets, luminaires, lamps, control gear, control cabinets/feeder pillars and associated cables which the MEW/Engineer shall direct to remove for later re-use by the MEW/Employer, shall be carefully dismantled by the Contractor, transported, unloaded and stacked at the depot of the Ministry of Electricity and Water. The Contractor shall notify the MEW/Engineer of all cases of damaged or otherwise defective equipment before its removal from the Site. The Contractor shall be liable for damage or loss caused to equipment during removal, handling, transport, unloading and stacking operations.

Concrete foundations and other items which are not required to be recovered shall be removed in accordance with Section 2 (Earth works) of these Specifications.

1401.13.3 Resiting of Existing Lighting Units and Control Cabinets/Feeder Pillars

After dismantling as described in Clause 1401.13.2 of these Specifications the Contractor shall remove to his shop those lighting units and control cabinets/feeder pillars for repairing/refurbishing which the MEW/Engineer shall direct for later re-use on the Contract Site.

All rusted area and loose paint finish on the column, bracket and control cabinets/feeder pillars for repairing/refurbishing shall be abraded down to the bare metal and the whole unit cleaned with spirit to remove dirt and grease. Non-galvanized steelwork shall be painted in accordance with Section 12(Metal works) of these Specifications in a colour to be notified by the MEW/Engineer. Galvanized columns and brackets shall have the zinc coating made good with two coats of an approved zinc-rich cold galvanizing paint..

Base compartment doors shall be completely removed before treating as described above. The drying times and methods of application of paint finishes shall be those recommended by the approved manufacturer.

Luminaires and electrical equipment for re-use shall be cleaned and fitted with new lamps, then tested for correct operation as described elsewhere in these Specifications. Minor repairs and replacements shall be carried out at no extra cost.

Only galvanized columns shall be used for all types of motorways and roadways. All internal wiriing inside the lighting columns shall be replaced by new wires.

All control cabinets/feeder pillars components shall be tested for proper functioning and repaired/replaced as necessary and as directed by the MEW/Engineer.

1401.14 SETTING OUT

The Contractor shall set out the lighting and electrical works accurately on site and in relation to all existing , relocated and new utilities and services before he commences any installation or erection. With the approval of the MEW/Engineer the Contractor shall make minor adjustments to the location of lighting masts, lighting

columns, control cabinets/feeder pillars and lighting cable runs to avoid and minimize conflicts with underground cables, utilities, conduits, pipes, ducts or other services.

Any minor adjustments made shall not affect the validity of the guaranteed performance submittals made under Clause 1401.09 of the Specifications.

No extra compensation will be allowed to the Contractor for any expenses incurred because of delay, inconvenience or interruption to his work resulting from compliance with the above requirements.

1401.15 LICENCE

Equipment manufactured by a company under licence will not be considered for use and all equipment shall be from the original manufacturers only as per the approved list of the Ministry of Electricity and Water.

1401.16 SPARE PARTS

1401.16.1 Contractor is to list in full detail, and supply, items for routine maintenance; 5% (or at least one piece) of installed quantities of each type of mast and column, luminaire, luminaire cover, lamp and respective control-gears, control cabinet/feeder pillar component, circuit breaker, fuse, cable, and a variety of bolts, nuts, lampholders, and small accessories, etc.

1401.16.2 Spare parts indicated in the Bills of Quantities (as listed by the Contractor), shall be supplied suitably packed for transportation to Site and long term storage, they shall include fastenings, lugs, and screws needed for their attachment. Identification labels shall be attached to the outside and also enclosed within the storage case.

1401.16.3 Any additional spare parts recommended by the manufacturers shall be listed in full detail.

1401.17 MEASUREMENT AND PAYMENT

1401.17.1 Method of Measurement and Basis of Payment

Measurement for the takeover of the existing lighting system , rectification of minor defects and maintenance shall be grouped together as an item.

Measurement for the maintenance of the permanent lighting system after completion shall be given as an item.

Removal of existing lighting masts/columns and associated equipment shall be enumerated stating the height, luminaire array, type of lamps and whether they are to be removed to the Ministry of Electricity and Water depot or removed to the Contractor’s shop for re-use on the Works.

Removal of existing control cabinets/feeder pillars and associated equipment shall be enumerated stating the type and the rating and whether they are to be removed to the Ministry of Electricity and Water depot or removed to the Contractor’s shop for re-use on the Works.

Measurement for removal of medium voltage cables (example 11KV cables) and delivery to MEW depot shall be measured in linear metre. Rates shall include removal of the cables and delivery to MEW depot, excavation, backfillig and making good the surface where required.

Payment rate for taking over of the existing lighting system, rectification of minor defects and maintenance shall be at the rate inserted in the Bills of Quantities which rate shall include everything necessary for the takeover of the system, the rectification of defects and faults and for the subsequent maintenance of the system for the duration of the execution of the Works or until removal.

Payment rate for removal of existing lighting masts/columns, control cabinets/feeder pillars and associated equipment shall be at the rates inserted in the Bills of Quantities for each unit removed. Rates shall include for removal and disposal of existing masts/column, control cabinets/feeder pillars foundations and backfilling of voids. For units removed to the Contractor’s shop for re-use on the Works. Payment shall also include for repair, renovation and testing of the units as specified. Payment shall not include for the re-siting of units which will be measured and paid for under respective Clauses of supply and installation of these Specifications as for new equipment.

Measurement of spare parts listed by the Contractor and recommended by the manufacturers for use beyond the Maintenance Period shall be grouped together as an item.

Payment for spare parts to be used beyond the Maintenance Period shall be at the rate inserted in the Bill of Quantities which rate shall include all spare parts listed by the Contrcator and recommended by the manufacturers.

Payment for spare parts required during the Maintenance Period shall be deemed to be included in the rates of the equipment to which they relate.

1401.17.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1401.1	Taking over of Existing Lighting System, rectification and maintenance	L.S
1401.2	Maintenance of new Permanent Lighting systems after completion	L.S
1401.3	Removal of existing lighting masts/columns and associated equipment to Contractor's shop for repair/refurbish and re-use (height/Nr. of luminaires/type and wattage)	nr
1401.4	Removal of existing control cabinets/feeder pillars and associated equipment to Contractor's shop for repair/refunbish and re-use (type) (rating)	nr
1401.5	Removal of existing lighting masts/columns and associated equipment to the MEW depot (height/Nr. of luminaires) (type and wattage)	nr
1401.6	Removal of existing control cabinets/feeder pillars and associated equipment to the MEW depot (type) (rating)	nr
1401.7	Removal of existing medium voltage cables of any type and size to MEW depot	m
1401.8	Spare parts as per list attached, in conformity with Clause 1401.16 (for use beyond the Maintenance Period)	item

1402 – TRENCH, BACKFILL AND INSTALLATION OF CABLE & ROAD CROSSING DUCTS

1402.01 GENERAL

This work shall consist of construction of trenches for the accommodation of the electric cable or ducts and backfilling at the locations shown on the Drawings. The Contractor shall include the furnishings of the backfill material and disposing of surplus material.

1402.02 CONSTRUCTION METHODS

The trench shall be excavated in a manner to prevent cave-ins and to a depth of not less than 750 mm. Excavated material shall be deposited at a sufficient distance so that the excavated material cannot fall back into the trench. The width of the trench shall be at least 450 mm. Where the electric cable enters the light column

foundation or conduit or other pipe, the bottom of the trench shall be built up to provide a smooth bed for the electric cable.

The electric cable or duct shall be placed in the bottom of the trench after all loose stones have been removed and all protruding stones have been removed or covered with soft backfill material as directed by the MEW/Engineer.

Cable or duct to be laid within central median barriers of a highway shall unless otherwise approved by the MEW/Engineer be placed at the time the infill to the barriers is at the appropriate level. Regardless of the method of cable or duct laying adopted within central median barriers, there will be no payment under the trenching item for the length involved. Cable/duct laid in the central medians without a barrier shall be laid two metres south or west of the center-line, as directed by the MEW/Engineer.

The backfill material shall be thoroughly compacted to a density equal to the existing ground or as approved by the MEW/Engineer in such a manner as not to injure the electric cable.

No stone or rock greater than 50 mm in maximum dimensions shall be allowed in any layer of backfill.

No material, which might cause settlement shall be placed as backfill. Deleterious substances, such as shells, clay lumps, and conglomerate and cemented particles shall not exceed 5% weight in any sample of backfill material.

Suitable material excavated from the trench may be used as backfill.

The MEW/Engineer shall inspect:

a. The trench before the electric cable or duct is placed in the trench.

b. The trench at any other time during excavation or back filling.

Trenches under and within 600mm of pavment, kerb, gutter, or kerb and gutter combination shall be backfilled and compacted as specified in Section 2 (Earthworks) of these Specifications.

The method and type of equipment to be used in compacting the backfill material shall be approved by the MEW/Engineer before any work is started.

For protection of underground cables of higher voltage levels (11kV and above), Cable covers shall be provided to BS 2484, with sand cushion around cable and a layer of 200 mm wide protective concrete bricks over the sand along the entire route of the cable. The bricks shall be laid in such a way to provide equal margin of cover on both sides of the cable. A warning tape shall be laid throughout the length of the trench.

Also, for high voltage cables, Cable identification/route markers shall be erected at 25m maximum spacing throughout the entire length of the cable trench route and at each bend or intersection. These shall be in accordance with MEW's standard practice and as approved by the MEW/Engineer.

1402.03 UNDERGROUND CABLE INSTALLATIONS IN uPVC CABLE DUCTS

A. uPVC Ductwork

All street lighting cables shall be installed in uPVC cable ducts at a depth of 75 cm.

For motorway/expressway systems, the cable ducts shall be of 100mm internal diameter (I.D.) having a minimum wall thickness of 3.2mm.

For local roads, the cable ducts shall be of 70.6mm I.D. having a minimum thickness of 2.6mm.

Minimum 2 Nos. of uPVC cable ducts shall be provided all through between the handholes, of which one will remain as spare duct. No cable shall be drawn in the spare duct and additional cable ducts shall be provided whenever the runs of cables in 100 mm I.D. ducts are more than three Nos. (3x35+2x16)mm² or more than four Nos. (2x16+1x10) mm² cables and the runs of cables in 70.6mm I.D. duct are more than two Nos. (3x35+2x16)mm² or more than three Nos. (2x16+1x10) mm² cables. . The ducts shall be encased at the joints by 1.0m of concrete mixture. The concrete blocks shall be cast-in-situ and shall have an envelope of minimum 10 cm. at the top and bottom and 7.5 cm. on the two sides.

The cables shall be continuous between lighting masts/columns without any joint and concrete handholes shall be provided at all changes of direction of the ducts, at both sides of any road crossing, at the base of all lighting masts/columns and also between all runs of ducts having lengths 60 metres and above, in order to facilitate drawing of the cables through the ducts. Where changes in direction are gradual, and with the permission of the MEW/Engineer, long radius ducts may be used. The minimum radius of curvature of the ducts shall be 10 metres.

Wherever street lighting cables to masts/columns and low voltage cables for supplying power to the control cabinets/feeder pillars cross asphalted carriageway or concrete pavement, the Contractor shall provide concrete encased duct banks comprising 2 way 100 mm. internal diameter uPVC ducts for street lighting cables and 2 way 150 mm. internal diameter duct for low voltage power cables at each crossing, whether such ducts are specifically shown on the Drawings or not.

The ductbank shall be encased in Class K140 concrete complying with Section 5 (Concrete Works) of these Specifications. Encasement of ductbanks shall provide a minimum of 150 mm of concrete in all directions.

The excavation and backfill of trenches for ductbanks shall be in accordance with Section 2 (Earthworks) of these Specifications.

The centerline of the ductbank shall be a minimum of 750 mm below the established grade levels.The uPVC ducts shall comply with the requirements of BS 3506, Class C, or BS EN 1452, class C (9 bar pressure rate) or equivalent. The ducts shall be inert, corrosion resistant and unaffected by water, oxidizing agents, aggressive soils, sand, fungal growth, and bacterial and electrolytic action. The ducts shall not ignite or support their own combustion. Manufactured smooth bends shall be allowed only at special situations with the approval of the MEW/Engineer. Minimum requirements shall be as follows: Non-sparking type, suitable for direct burial in ground, minimum tensile strength 500 kg/cm² and minimum impact strength of 5kg/cm².The uPVC ducts shall have enlarged socket ends to receive conduit without any reduction in the internal diameter at joints and to facilitate installation and solvent weld.Provide bell-ends at handhole junctions for smooth cable entry.

The ducts shall be supplied in 6m lengths and shall be joined with an approved solvent cement conforming to BS 4346, or equivalent. The ducts shall not be exposed to direct sunlight, either in store or in an unfilled trench, for more than seven days without suitable protection to the approval of the MEW/Engineer.

Suitable duct spacers shall be provided in all cases throughout the lengths of the cable ducts at intervals as necessary to keep the ducts properly aligned inside the trenches and in concrete encasements. At all entry and exit points of the ducts in the handholes, manholes and concrete foundations for lighting masts/columns and control cabinets/feeder pillars, duct bell mouths shall be provided.

All the works of excavation of trench, laying of cable ducts, casting and installation of handholes, earth-pits, etc. shall be inspected by the MEW /Engineer before the cables and wires are permanently trained in the cable ducts, handholes, earth-pits or lighting units. Warning tapes shall be provided at the depth of 30 cm. and warning notice shall be written on the warning tapes. Duct route markers of concrete shall be provided all along the duct routes in conformity with MEW practice.The Contractor shall pressure test approximately 10% of the ducts, between handholes, at a pressure equivalent to a 10m head of water, using a test method and equipment approved by the MEW/ Engineer. The pressure must be maintained without measureable loss for at leat ten minutes following shut-off of the pump.

If the ducts fail the above test, the Contractor shall, at his own cost, repair or replace the ducts as directed by the MEW/Engineer

Where ducts of various sizes are required, the outside diameter and minimum wall thickness shall be as given in Table 1402.03.

The construction of duct/conduit and duct/conduit fittings shall insure sufficient strength and rigidity to enable the duct/conduit to resist damage during shipment, rough handling, installation and use.

The Contractor shall submit proof that the uPVC duct or conduit and duct/conduit fittings he proposes to supply conform to the requirements of above standards.

uPVC Ducts / Conduits	Nominal Size (mm)	Outside Diameter (mm)	Minimum wall Thickness (mm)
Conduit	38	48	2.2
Cable Duct/ Conduit	50	70.6	2.2
Street Lighting Cable Duct for Motorways / Expressways	100	110	3.2
Street Lighting Cable Duct for Local Roadways	70.6	75	2.6
Road Crossing Duct for Street Lighting Cable	100	110	4.5
Road Crossing Duct for Low Voltage Power Supply Cable for Control Cabinets / Feeder Pillar	150	160	5

Table 1402.03 – Dimensions of uPVC Underground Cable Ducts and Conduits

B. Handholes

The overall dimensions of the handholes shall be 830 mm (L) x 680 mm (W) x 950 mm (D) with a clear opening of 600 mm x 450 mm. The handholes shall be pre-cast from Class K-300 concrete and frames and covers shall be from Polymer Matrix Composite materials. The frames shall have minimum 4 Nos. of suitably sized robust anchors for anchoring with the concrete. The casting of the handholes shall be performed together with the frame at one time and separate fixing of the frame at site will not be accepted.

The Polymer Matrix Composite frames and covers shall be medium duty type, able to carry a load of minimum 180 KN and must withstand Kuwait's maximum temperature under the open sun, which reaches up to a maximum of 84oC.

The covers of the handholes shall be lockable type, provided with necessary slots with lifting handles and shall be engraved with letters "MEW-SL" of minimum 5cm. height and 5mm deep. The covers shall also be embedded with a suitably sized metal piece at the centre position in order that the handholes can be easily located in case buried under the sand.

The manufacturer shall guarantee the Polymer Matrix Composite frames and covers for a period of minimum ten (10) years against any defect and discoloration.

The Contractor shall submit sample of reinforcement steel for the handhole along with a sample of complete handhole with Polymer Matrix Composite frames and covers for the MEW's/Engineer's approval. No works shall be started at site until and unless the MEW's/Engineer's approval is gained on the samples. The handholes shall be installed with their tops aligned with the finished pavements. However, for unfinished ground levels, the top of the handholes shall be at 10 cm from the ground level and/or as directed by the MEW/Engineer.

Foundation preparation and backfill shall be in accordance with Section 2 (Earthworks) of these Specifications. The galvanized steel frame, cover and fasteners shall meet the requirements of Section 12 (Metal Works) of these Specifications.

Where so indicated on the Drawings a drain shall be constructed in the bottom of the handhole with clean, pit – run gravel all retained on a 4.75-mm sieve.

1402.04 MEASUREMENT AND PAYMENT

1402.04.1 Method of Measurement and Basis of Payment

Subject to the provisions of Clause 1402.02 hereabove, excavation for cable trenches, other than for cables drawn through ducts, shall be measured by the meter run irrespective of depth and the number of cables in the trench.

Excavation for cable drawn through ducts other than those drawn through duct banks crossing asphalt carriageway or concrete pavements will not be measured separately, but included in the rates of the ducts laid therein.

Measurement of pair of street lighting ducts shall be by the metre run along the centre line of the ducts between handholes or manholes.

Measurement of concrete encased ductbanks shall be by the metre run for each duct configuration and type separately irrespective of the depth of laying. Subject to the provisions of Clause 1402.03 hereof, measurement of uPVC ductwork shall be made for the number of linear meters of multiple uPVC duct banks of each size as shown on the Drawings or as directed by the MEW/Engineer, (excluding handholes, manholes or other civil works enumerated or measured separately under this or other Clauses of this Specification), complete with all required accessories acceptably supplied and installed by the Contractor in accordance with the Specification.

Measurement of excavating and backfilling of trenches for concrete encased ductbanks shall be by the meter run for each ductbank configuration (excluding the length of handholes / manholes etc.,) and in compliance with Clause 1702.08 of Section 17 (Utilities Structures) of these Specifications.

Measurement for a pair of ducts laid in concrete slabs shall be in linear meters of required size subject to provisions of Clause 1402.03 hereof.

Electrical handholes, other than handholes to ground rods, shall be enumerated irrespective of size.

Payment rate for trenches for directly buried cable, shall be at the rate inserted in the Bills of Quantities which rate shall include for excavation in all types of soil and rock, all necessary temporary works, dewatering, backfilling, compaction, and the use of approved surplus excavated material for filling (including compaction) in other areas of the site and for disposal of surplus excavated material, and subject to the provisions of Clauses 1402.01 and 1402.02 of these Specifications.

Where a pavement is to be re-opened to traffic (either temporarily or permanently) on completion of the work, the removal and reinstatement of existing pavement courses, precast concrete tiles/blocks and street furniture shall be executed and paid for according to Clause 1701of Section 17 (Utilities Structures) of these Specifications. Payment will be made under Section 14 of the Bills of Quantities.

Where a pavement is not to be so re-opened to traffic, measurement for removal of existing pavement, precast concrete tiles/blocks and street furniture shall be according to Clause 207.08 of Section 2 (Earthworks) of these Specifications, and payment shall be made under Section 2 of the Bills of Quantities.

Payment for pair of street lighting ducts shall be at the rate inserted in the Bills of Quantities which rate shall include for all labour,plant and material,and everything necessary for proper execution of the works ,including excavation,backfilling and disposal of surplus excavated material ,grading the trench bottom,upholding the sides of the excavation ,de-watering, encasement in concrete at 2.5m centres,and all incidental work in connection with the execution.

Payment rate for concrete encased ductbanks of configuration and classification shown on Drawings shall be at the rates inserted in the Bills of Quantities which rates shall include for all labour, plant, materials and everything necessary for the proper execution of the work, including supplying and laying the ducts and split ducts, all necessary jointing accessories, fittings, cutting of ducts, waste allowance, connections to existing fittings, the supply and laying of concrete including laying the concrete bed under the pipes in a separate operation as necessary, all necessary formwork, testing and all other incidental work in connection with the construction, and including the provision and installation of draw wires, end plugs, marker slabs, fence posts and indicator posts where specified.

Payment rate for trench excavation for each of the separate configuration/classification of ductbanks shall be at the rate inserted in the Bills of Quantities, in accordance with Clause 1702.08.1 of Section 17 (Utilities Structure) of these Specifications which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including excavation, hand excavation where necessary for extending existing ducting or protecting existing cables, backfilling, disposal of surplus excavated material, grading the trench bottom, upholding the sides of the excavation, de-watering and all other incidental work in connection with the construction.

Payment rate for ducts buried in slab or concrete shall be made for the number of linear meters of each size measured as provided above and shall constitute full compensation for supplying, installing, connecting and terminating in handholes or manholes at ends of ducts where required including all accessories, fittings waste allowance etc. but excluding concrete work, and to the satisfaction of the MEW/Engineer.

Payment rate for handholes shall be at the rate inserted in the Bills of Quantities which rate shall include for excavation in any type of soil or rock, concrete, reinforcement, formwork, cover and frame, conduit, etc, backfilling, disposal of surplus excavated material subject to Clause 1402.03 herein above and as shown on the Drawings.

1402.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1402.1	Trench for directly burried cables	m
1402.2	Trench for concrete encased ductbank(ducts configuration)	m
1402.3	Concrete encased ductbank (type) (configuration) (duct diameter)	m
1402.4	uPVC duct laid in concrete slab or structure (configuration) (duct diameter)	m
1402.5	uPVC ducts for street lighting directly buried (configuration) (duct diameter)	m
1402.6	Handhole	nr
1402.7	Removal and reinstatement of existing pavement courses, precast concrete tiles/blocks and street furniture according to Clause 1701 of these Specifications	m

1403 - FOUNDATIONS FOR LIGHTING MASTS AND COLUMNS

1403.01 FOUNDATIONS FOR LIGHTING MASTS AND COLUMNS

This work shall consist of the construction of reinforced concrete foundations for lighting masts/columns in accordance with the Drawings and these Specifications, or in accordance with column or mast manufacturer's recommendations which may be substituted with the approval of the MEW/Engineer. Foundation for lighting masts/columns shall be cast in situ using Class K300 concrete except for columns on concrete parapets on the bridges or other structures which shall be as shown on the Drawings.

For all foundations, the number of anchor bolts, bolt circle diameter, anchor bolt dimensions and flange plate material shall be such as to withstand the loading described elsewhere on the Drawings and in these Specifications. All standard anchor bolts shall meet the requirements of ASTM F1554 code 55. The projecting portion of the anchor bolt and the nuts and washers shall be treated by the hot dip-galvanizing method in accordance with ASTM 153 or other such protective system as may be approved by the MEW/Engineer. The Conduit for all masts shall consist of two 75mm outside diameter uPVC conduits.

The holes for cylindrical foundations shall be made by drilling with an auger of the same diameter as the foundations. The foundations shall be cast-in-situ and allowed to cure for at least seven days before the light column is erected. Concrete shall be deposited against the soil. If soil conditions require the use of a liner to form the hole, the liner shall be withdrawn as the concrete is deposited. Forms shall include templates to hold anchor bolts and conduit secured in proper place during the casting of concrete.

All concrete shall be class K300 and concrete work shall conform to all requirements of Section 5 (Concrete Works) of these Specifications.

All areas around the concrete foundations shall be compacted as specified in Section 2 (Earthworks) of these Specifications before any paving or tiling is carried out.

The foundations shall be so cast that the top of the concrete remains 10 cm. above the finished ground level or tiled pavement of the median and the side-walk and/or as approved by the MEW/Engineer. The foundations shall

be free from all cracks or voids and shall have a fully aesthetic finishing in all respects. Only potable water shall be used for all concretes.

All lighting masts/columns after erection and before any grouting is performed shall be vertically aligned. The Contractor shall have in his possession two theodolites or other modern equipment for this purpose, which he shall simultaneously employ to have bearings from two right-angled directions while correcting the vertical alignment of the masts/columns. The MEW/Engineer reserves the right to reject part or whole of the installation in case lighting masts/columns are not aligned properly.

1403.02 SPECIAL FOUNDATIONS

Where special foundations are required to avoid conflict with other utilities, full design proposals and structural calculations shall be submitted for the MEW's /Engineer's approval.

Any such special foundations that are required shall be considered as a variation, and valued accordingly.

1403.03 REQUIREMENTS FOR CONCRETE WORKS

All concrete works of lighting columns, masts and control cabinets/feeder pillars foundations, pre-cast manholes and handholes and other miscellaneous concrete works shall meet with the requirements of Section 5 (Concrete Works) of these Specifications and shall be adequately cured with potable water consecutively for seven (7) days. All concrete works shall be covered with thick canvas clothes and curing shall be performed two times a day as a minimum, once in the early morning and once in the evening or as directed by the MEW/ Engineer. The Contractor shall make available necessary water tankers at the Site for this purpose.

The Contractor shall apply rubberised bitumen to the buried surfaces of all pre-cast concrete works like, manholes, handholes, earth-pits, etc. as a protective painting. The rubber bitumen emulsion shall be a water bound emulsion with a minimum 60% total solids content by volume, comprising bitumen with fine particles of rubber. Not less than 10% nor more than 20% of the total solids shall be rubber. The consistency shall be such that it can be applied to the surface by brush at normal temperature. The Contractor shall submit material specifications and samples of rubber bitumen for MEW's/Engineer's approval.

All concrete surfaces shall be cleaned before applying the rubberised bitumen. The priming coat shall be made by mixing 0.23 Kg. of approved powder or equivalent liquid detergent with 45 litres of clean water and adding this to 4.5 litres of emulsion. The priming coat shall be applied at the approximate rate of 9 litres per 30 sq.m. The second coat of undiluted emulsion shall be applied at the rate of 9 litres per 15 sq.m. as soon as the priming coat is dry.

1403.04 NUMBERING OF LIGHTING MASTS, COLUMNS AND CONTROL CABINETS/FEEDER PILLARS

All lighting masts, columns and control cabinets/feeder pillars shall be numbered with Black or other colour requested by MEW/Engineer, stickers or Spray Paints to a position as directed and approved by the MEW/Engineer. The stickers or paints shall be fully suitable for Kuwait's extreme temperature and weather conditions and will not damage or deteriorate within at least five (5) years. The Contractor shall submit a written guarantee for this. The height of the numbers for all lighting masts and columns of 16 m. height and above and for the control cabinets/feeder pillars shall be 15 cms. and for 12, 10, 8, & 6 m columns shall be 12 cms. Two (2) sets of numbering shall be provided for the lighting masts, columns and the control cabinets/feeder pillars located at the medians in order to read the same from either side of the carriageway. The numbering of lighting masts and columns shall include mast/ column No., Circuit No. and the control cabinet/feeder pillar No., in an order shown below or as directed by the MEW/ Engineer.

MAST/COLUMN NO. 1,
CIRCUIT NO. 1,
C.C. /F.P. NO.1

1403.05 MEASUREMENT AND PAYMENT

1403.05.1 Method of Measurement and Basis of Payment

The approved civil work for the lighting column/high mast reinforced concrete foundation shall be enumerated and included with the respective type of mast or column item as per detail Drawings, complete with template, bolts, nuts, lead-in ducts for cabling and any accessory specified or required as per the column/mast detail approved, and subject to the provisions of Clauses 1403.01 and 1403.02 above.

Payment rate shall be included with the respective rate for column or mast item in the Bills of Quantities, which includes excavation and backfilling,compaction, supply of materials, labor, equipment, tools, supplies and other work items necessary for the proper support and completion of the work as specified.

1404 - ELECTRIC CABLES

1404.01 ELECTRIC SERVICE CABLES, 600/1000 VOLT GRADE

1404.01.1 Unarmoured Electrical Service Cables, 600/1000 Volt grade

Electrical cable between control cabinets/feeder pillars and light columns or illuminated signs, and between electrical handholes and junction boxes at the abutment wall shall be unarmoured, 600/1000 volts, stranded copper, cross-linked polyethylene (XLPE) insulated (for motorway/expressway lighting systems) and Type-TI3 Polyvinyl Chloride (PVC) insulated (for local roads lighting systems), Type-9 PVC oversheathed conforming insofar as they are applicable to the requirements of IEC60502, IEC60811, IEC60885, BS EN50363-3:2005 and BS7655-4.2:2000 except where otherwise specified.

Conductors shall consist of stranded copper conductors, circular in shape, cross-linked polyethylene (XLPE) or polyvinyl chloride (PVC) insulated and over sheathed with PVC. The conductor sizes and cores shall be as shown on the Contract Drawings, and shall be from among the following:

a. 5 core, 3 x 35 mm² + 2 x 16 mm²
b. 5core, 3 x 25 mm² + 2 x 16mm²
c. 3 core, 2 x 16 mm² +1 x 10mm²
d. 3 core, 3 x 6mm²
e. 1 core, 1.5mm^2 control cable for energy saving system/connection (see Drawings)

Cables conforming to comparable international standards may be considered by the MEW/Engineer. All applicable tests listed in IEC60502, IEC60811, and IEC60885 shall be performed on the cable at the manufacturer's plant and certified test results shall be submitted to the MEW/Engineer with each shipment delivered to the project Site.

Cables are to be supplied in 500 m non-returnable drums.

1404.01.2 Armoured Electrical Service Cables, 600/1000 Volt Grade

Where specified, armoured electrical cable between control cabinets/feeder pillars and lighting columns and between electrical handholes and junction boxes at the abutment walls shall be used . Cable shall be single wire armoured, 600/1000 volts, stranded copper, cross-linked polyethylene (XLPE) insulated, PVC oversheathed conforming to the requirements of IEC60502, IEC60811, and IEC60885.

Conductors shall consist of stranded copper conductors, circular in shape, cross-linked polyethylene (XLPE) insulated and oversheathed with PVC. The conductor sizes and cores shall be as shown on the Contract Drawings and as given above in Clause1404.01.2

Cables conforming to comparable international standards may be considered by the MEW/Engineer. All applicable tests listed in IEC60502, IEC60811, and IEC60885 shall be performed on the cable at the manufacturer's plant and certified test results shall be submitted to the MEW/Engineer with each shipment to the project Site.

Cables are to be supplied in 500 m non-returnable drums.

Note: Clause 1404.01.2 is applicable to breakaway column assembly cable.

1404.02 ELECTRIC FLEXIBLE CABLES, 300/500 VOLT GRADE

The flexible cables specified here are required for the installation inside the galvanized steel street lighting columns (between the control gear panels installed at the base compartment and the luminaires) where the temperature and humidity conditions are extreme and severe.

The flexible cables shall be Type TI3 PVC insulated and Type TM3 sheathed 300/500 volt grade, circular, 3core, with 1.5mm² copper conductor and shall comply with BS 7655-2.2, BS 6007:2006, BS 6500:2000, IEC 60811, BS EN50363-3:2005 and BS EN 50363- 4.1:2005

The flexible cables shall be tested in accordance with the relevant standards..

The flexible cables shall be supplied in 100 m non-returnable reels.

Cables conforming to comparable international standards may be considered by the MEW/Engineer. All single core applicable BS or IEC tests shall be performed on the cable at the manufacturer's plant and certified test results shall be submitted to the MEW/Engineer with each shipment of any material to the project Site.

1404.03 ELECTRIC FLEXIBLE CABLES, 450/750 VOLT GRADE

The flexible cables specified here are required for the installation inside the luminaires with integral control gear where the temperature and humidity conditions are extreme and severe.

The flexible cords shall be heat resistant silicon rubber(150°C) insulated, with fiberglass braided sheath, 450/750 volt grade, circular, with copper conductor of adequate cross-section and shall comply with BS 7655-2.2, BS 6007:2006, BS 6500:2000, IEC 60811.

The flexible cords shall be tested in accordance with BS 7919:2001.

The flexible cords shall be supplied in 100 m non-returnable reels.

Cables conforming to comparable international standards may be considered by the MEW/Engineer. All single core applicable BS or IEC tests shall be performed on the cable at the manufacturer's plant and certified test results shall be submitted to the MEW/Engineer with each shipment of any material to the project Site.

1404.04 ELECTRIC CABLES, 450/750 VOLT, CROSS–LINKED POLYETHYLENE (XLPE) INSULATED

All single core electric cables within control cabinets/feeder pillars, control gear panels, cut-outs, underbridge lighting and sign lighting (but excluding between control gear and the lamps) shall have annealed copper conductors to IEC 60228 and shall be cross-linked polyethylene insulated to IEC60502-1.

The identification of the cores shall be as specified under Clause 1404.08.5 of these Specifications, The conductor shall be insulated with cross-linked polyethylene moisture and heat resistant material having a temperature rating of 90˚ C. All applicable BS or IEC tests shall be performed on the cable and certified test results shall be submitted to the MEW/Engineer for approval prior to shipment of cable to the project Site. Cables are to be supplied in 100-m non-returnable reels.

Cables conforming to comparable standards may be considered by the MEW/Engineer.

1404.05 ELECTRIC CABLES FOR 25 M TO 40 M HIGH LIGHTING MASTS

Electrical cables between the service cutout at the mast base compartment and the luminaires for the 25 m to 40m high lighting masts shall be multi-core power cable to IEC60502-1 and IEC 50214, 600/1000 V grade or as otherwise approved. The cable shall be entirely suitable for the bending and load carrying stresses involved under the arduous climatic conditions described in Clause 1401.06 of these Specifications.

1404.06 PACKING

All cables shall be delivered to site wound on strong wooden cable drums provided with wooden battens to protect the cable from damage or in such other containers as may be approved by the MEW/Engineer. Both ends of the cable lengths shall be brought outside the drum for testing purposes and properly protected.

All wooden drums shall become the property of the Ministry of Electricity and Water and shall be delivered by the Contractor to the Ministry of Electricity and Water stores as directed by the MEW/Engineer.

Except where the exact length of cable is marked on the outside of the cable drum or container the length of cable shall not vary from the nominal length by more than 2%.

1404.07 MARKINGS

All cable drum shall be clearly engraved in the English language as follows:

a. Name of manufacturer
b. Sizes and number of conductors
c. Voltage
d. Drum number
e. Length of cable
f. Contractor's order number
g. Weights – net and gross
h. Shipping identification marks
i. Inspector's certificate identity marks
j. Address: Contractor, c/o Ministry of Public Works, Kuwait (Arabian Gulf)
k. Direction of rotation
l. The "A" and "Z" ends of the cables to indicate the lay of the cable cores.

In addition to the above, two metallic sheets each 160 mm x 120 mm fixed on both sides of the drum by 4 No. screws should be provided with the cable type, length, size and order number engraved on it in English.

1404.08 TECHNICAL REQUIREMENTS AND SPECIFICATIONS

1404.08.1 Conductors

Unless otherwise specified or shown on the Drawings, cables and other feeders shall have copper conductors. Cable conductors shall be stranded for sections 1.5 mm² and above, based on IEC 60228 Class 2. Signal and control cables shall have solid conductors unless otherwise specified. Flexible cords shall have finely stranded conductors. Conductors of single core cables 25 mm² and above shall be compacted. Multi-core cables 35 mm² and above shall be sectoral shape.

1404.08.2 Insulation

Heat resisting cross-linked polyethylene, PVC or rubber, as specified, shall be used for the insulation of the conductors, excepting those in luminaires, where special heat resisting cables have to be used. . The cross-linked polyethylene insulation shall be free from foreign materials and defects liable to reduce the electrical strength of the insulation. It shall be applied by an extrusion process and shall form a compact homogenous body.

The thickness of insulation shall be as specified in the relevant IEC and/or British Standard.

The thickness of type TI3 PVC insulation shall be as follows:

5-core cables : 1.2 mm (phase cores), 1.0mm (neutral and earth cores)

3-core cables : 1.0mm (phase, neutral and earth cores)

1404.08.3 Laying-Up

The cores of the cables shall be laid with a right hand direction of lay. Where necessary, non-hygroscopic fillers, which may be applied integrally with the sheath of the cables, shall be used to form a compact and circular cable. There shall be no adhesion between the sheath and insulation of the cable and where the sheath is applied integrally with the fillers it shall be possible to strip it from the cable without damaging the insulation of the cores.

1404.08.4 Sheath

The sheath shall consist of extruded PVC, black in colour, and shall withstand deterioration while in the storage and service conditions outlined in Clause 1401 of these Specifications. The PVC used for the sheath shall be Type 9 to BS7655-4-2:2000.

The thickness of sheath of all the cables shall be as specified in the relevant IEC and/or British Standard.

The thickness of Type 9 PVC oversheath shall be minimum 2.5mm.

1404.08.5 Identification of Cores

The identification of cores in all cases shall be as follows:

a. 5-core cables : Red, Yellow, Blue (3 phases) ,
   Black (Neutral) , Green or Green/Yellow (Earth)
b. 3-core cables : Red (Phase) , Black (neutral) ,
   Green or Green/Yellow (Earth)
c. 1 – core control cable : Grey

1404.08.6 Current Ratings

The current ratings of cables for the site and installation conditions mentioned above shall be stated.Where ratings are specified for any standard conditions appropriate adjustment factors shall be stated.

1404.08.7 Short Circuit Ratings

Short circuit current curves shall be submitted as required by Clause 1401.09 of these Specifications. It is to be assumed that the conductor is at its maximum operating temperature of 90° C for XLPE insulatd cables before the occurrence of the short circuit. The magnitude of the short circuit current in the conductor for the maximum duration of 0.5 second must be limited by a maximum conductor temperature of 250° C (for XLPE insulation).

The formula used in evaluating the short circuit current shall be stated.

1404.08.8 Guarantee

A guarantee certificate shall be submitted as required by Clause 1401.09 of these specifications to guarantee that the offered cables will give continuous trouble-free service at Kuwait's extreme temperature and climatic conditions and that any cable that will fail, burn out or get damaged within a period of three (3) years from the date of commissioning of the project will be replaced and reinstalled by the Contractor free of charge.

A guarantee certificate shall also be submitted to guarantee that the cables particularly the outer PVC sheathing will withstand the Kuwait's extreme temperature under the sun when stored on their drums in the open for a period of 18 months.

1404.08.9 Quantity Marking on Underground Cables on Drum

The cables shall be marked each 5 meters length (length commencing e.g. from top end 500 – 495 – 490 - 485 - etc. and ending with 5 meters). The letters "MEW" shall be clearly marked next to each length marking.

1404.09 JOINTING 600/1000 VOLT CABLES

This Clause covers the use of cable jointing kits employing cold- pouring, solid-setting resin, which are suitable for direct burial in the ground. Underground joints will be avoided whenever possible by looping cables in and out of lighting columns, but where shown as necessary on the Drawings these joints shall be made underground by skilled cable jointers using molded plastic joint box kits of an approved type filled with cold-pouring resin and approved mechanical connectors.

Joints employing sweated or compressed connections will not be approved.

Jointing kits shall contain the complete set of materials required to make the joint on site, including:

a. Two part casing, either transparent or with filler hole large enough to inspect all clearances.
b. Casing sealing material.
c. Resin and hardener, which during setting shall not exceed the maximum permissible temperature for continuous operation of cable.
d. Conductor mechanical connectors suitable for the maximum current rating of the cable to be jointed.
e. Conductor insulating material.
f. Earth/armouring continuity strap and clamps.
g. Complete and easy- to-follow instructions.

The Contractor shall give adequate notice and shall provide facilities for the MEW/Engineer to inspect each joint both before filling and before burying.

Splicing will not be accepted as a way of jointing cables. Only approved clamping devices shall be used.

A minimum length of 1000 mm of additional cable shall be provided adjacent to each joint on both the incoming and outgoing cable runs to allow for future remaking of the joint in the event of damage.

1404.10 CABLE AND CORD TERMINATIONS

All terminations of all cables and flexible cords shall be mechanically and electrically sound. They shall be protected against mechanical damage and shall securely contain and anchor all the wires of the conductor without imposing any mechanical strain on the cable or cord or on the terminal.

Terminations shall be insulated for the full voltage of the circuit of which they form part. Where the design of the terminal is such that live parts are exposed, such parts shall be shrouded to prevent accidental contact with them. Terminals on a common board or block shall be separated from each other by barriers, which increase creepage distance and reduce the possibility of short circuits. Terminals shall be located or shielded so that if one wire of a stranded conductor escapes from a terminal when the conductor is fitted, the loose wire cannot make accidental contact with any other metal part.

Insulation shall not be stripped back further than is necessary to make a sound electrical connection. The sheath of multi core cables shall not be stripped back further than is necessary to allow the separate cores to reach their corresponding terminals. Where cable glands are used they shall securely retain the outer sheath or armour of the cable without damage.

Where the cable is terminated in a lug, a sleeve shall be provided over the end of the insulation and the barrel of the lug to provide additional support and prevent excessive bending of the wire where it enters the barrel of the lug.

Terminations shall be capable of carrying the full load current of the circuit of which they form part without a significant voltage drop across the termination or appreciable heating of the termination. The contact resistance shall not exceed 0.001 ohm.

For luminaires the terminations shall be enclosed in heat resistant non-flammable silicon, glass fibre or other approved insulating material.

The termination shall clamp the conductor between metal surfaces with sufficient contact pressure to ensure a good electrical connection but without damaging the conductor. Screws shall have at least two full threads in engagement when clamping a conductor. The fixed part of the terminal shall be secured against rotation, which may occur when the clamping means are tightened or loosened.

Connections in which the bare conductors of two or more cables or cords are twisted together, whether enclosed in a connector made for the purpose or not, shall not be used.

1404.11 CABLE ENTRIES (CONTROL CABINETS / FEEDER PILLARS, CUTOUT BOXES, ABUTMENT BOXES ETC)

All cable entries into equipment shall be effectively sealed with compression type cable sealing glands or conduit glands to the approval of the MEW/Engineer.

1404.12 MEASUREMENT AND PAYMENT

1404.12.1 Method of Measurement and Basis of Payment

Measurement for street lighting cable shall be made in linear meters for each size and type of cable as shown on the Drawings or as directed by the MEW/Engineer, complete with required accessories, (excluding excavation and backfill), providing and laying of protection bricks and warning tape (as and where applicable), cable identification and route markers (as and where applicable), all types of cable jointing and terminations, including accessories such as clamps, channels, clips, connectors, lugs, tapes ,delivering of empty wooden cable drums to MEW's store and any other item which is not stated above but is considered necessary for completion of the work professionally to the satisfaction of the MEW/Engineer.

Cables shall be measured by the meter run along the center line of the cable between termination points stating the type and size of cable and whether installed above or below ground. An allowance of two (2) meters, irrespective of the length actually provided, shall be added to the length of cable for each termination point.Also an allowance of one (1) meter shall be added to the length of each cable passing through each handhole or manhole. In case cables in the medians are not running along the centre line on the median, necessary allowance for the offset shall be added.

Measurement for undercrossing lighting cable shall be made for the number of linear meters for each size and type of cable as shown on the Drawings or as directed by the MEW/Engineer, complete with required accessories including pulling of cable in already installed/buried conduit or uPVC ducts in slab, all types of jointing and terminations ,delivering of empty wooden cable drums to MEW's store, and any other item which is not stated above but is considered necessary for completion of the work acceptably supplied and installed by the Contractor.

The amount of completed and accepted cable work as provided for above will be paid for at the unit rates for 'cables' in the Bills of Quantities which rates shall be full compensation for supplying materials, installing, testing (excavation and backfill separately measured and paid for), putting into operation, and for labor, equipment , tools, supplies and other work items necessary for the proper completion of the work as specified above and in the General Conditions of Contract.

1404.12.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1404. 1	Electrical cable (type) (voltage) (size)	m

1405 - EARTH BONDING AND GROUNDING

1405.01 GENERAL

Metal conduit, non-metallic conduit, grounding wire, ballast, control cabinets/feeder pillars, sign switches, anchor bolts and metal masts/columns shall be made mechanically and electrically secure to form a continuous system with all metal components effectively grounded. Grounding jumpers shall be copper wire or copper strap with the same cross-sectional area as 16 mm² for lighting system and 10 mm² for all other systems.

Bonding of light masts/columns shall be by means of bonding jumpers attached to brass, bronze or stainless steel bolts installed in the lower portion of the shaft as shown on the Drawings. Grounding of metal conduit, service equipment and neutral conductor at service points shall be in accordance with details shown on the Drawings. For bonding purposes a ground wire shall be installed in each duct and conduit. The service equipment enclosure shall be bonded to the ground terminal. Bonding of metallic conduit in concrete handholes or pull boxes shall be by means of lock nuts, one inside and one outside of the box or by threaded bosses or hubs on the boxes.

A ground rod shall be furnished and installed at each service point and at each lighting column/mast and control cabinet/feeder pillar. Ground rods shall be 19 mm diameters and minimum 3 m long copper clad galvanised steel, manufactured in full compliance with the requirements of the BS EN 50164-2:2008. All rods shall be housed in concrete handholes fitted with cover and frame of approved type. The handhole at the base of a lighting column/mast shall also be used as an earth pit and a separate earth pit is not required except for the control

cabinet/feeder pillar. The tops of the ground rods shall be a minimum of 450 mm below finished ground level and the rods shall be properly connected to the grounding wire.

The lighting masts/columns and the control cabinets/feeder pillars shall be connected to the earth electrodes respectively by 16 and 35 sq. mm bare copper conductors and all connections shall be properly soldered and greased in an approved manner. The bonding between the control gear panels, cut-outs, etc. for lighting masts/columns of 12 meters height and above shall be by 16 sq. mm. Green or Green/Yellow coloured PVC insulated wires, and by 10 sq.mm. wires for 10 metres height columns and less.

The Contractor shall test and prove for all grounded systems that the resistance to earth does not exceed 0.5 ohm. The test shall be done in the presence of the MEW/Engineer at a time chosen by the MEW/ Engineer. The ground rods shall be driven to a sufficient depth to achieve the required low resistance under summer conditions and additional rods shall be used if necessary at no extra cost whatsover. Artificial conditions will not be accepted during testing.

Lighting masts 25 m to 40 m high, light columns 22 m high and sign support structures which span the carriageway shall be provided with a separate system of earthing as a protection against lightning. This shall comply with the requirements of BS 62305:2006. The connection to the earth electrode for lightning protection shall be by 70 sq-mm bare copper wire.

The use of metallic conduit as an earth continuity conductor will not be accepted.

Separate earthing shall be provided for each item of control equipment within lighting masts/columns, each connected to a central earthing point.

1405.02 MEASUREMENT AND PAYMENT

1405.02.1 Method of Measurement and Basis of Payment

Cable shall be measured in accordance with Clause 1404.12 of these Specifications.

Trench and backfill shall be measured in accordance with Clause 1402.04 of these Specifications.

Ground rods shall be enumerated.

Cable shall be paid for at unit rates inserted in the Bills of Quantities which rates shall include cable jointing, cable terminations, flexible conduit where required, and delivery of empty wooden cable drums to the Ministry of Electricity and Water stores.

Payment rate for trenching and backfill shall be in accordance with Clause 1402.04 of these Specifications

Payment rate for ground rods shall be at the rate inserted in the Bills of Quantities which rate shall include for the supply and installation of the ground rod, connecting the cables, testing and proving resistance, and handhole complete with cover and frame.

1405.02.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1405.1	Insulated Grounding Cable (…. mm^2)	m
1405.2	Trench and Backfill	m
1405.3	Ground Rod	nr

1406 - CABLE TRAYS, TRUNKING AND CONDUIT

1406.01 STEEL CONDUIT ATTACHED TO OR EMBEDDED IN STRUCTURES

1406.01.1 Description

The work shall consist of furnishing and installing 25 mm, 32 mm, 38 mm, 50 mm or 74 mm diameter rigid, heavy duty galvanised steel conduit as shown on the Drawings and as approved by the MEW/ Engineer. It

includes conduit couplings, fittings, junction boxes, concrete junction boxes with extension rings, bushings and all hardware for attaching or mounting.

1406.01.2 Materials

Rigid, heavy-gauge galvanised conduit shall comply with the requirements of applicable British Standard Specification or any equivalent international standard. Junction boxes to be attached to structures shall be cast iron, hot-dipped galvanised and listed as raintight. Junction boxes to be embedded in concrete shall be made of galvanised sheet steel gauge No. 14.

Hardware and fittings shall be approved by the MEW/Engineer and shall be appropriate in design for the required application. Conduit clamps shall be of malleable iron. Conduit fittings such as pulling elbows, entrance fittings, etc., shall be cast from malleable iron. Flexible conduits used for connections to undercrossing luminaires and at expansion joints of structures shall be watertight, made of square-locked galvanised metal tubing.

1406.01.3 Installation

The conduit shall be embedded in concrete structures. Conduit attached to structures will be considered only as an alternative when embedding cannot be accomplished because of the design of the structure.Conduits installed inside the bridge box girders or on overhead sign support structures shall be securely fastened. All conduit shall be rodded and swabbed to remove all dirt and other foreign materials. Bushings shall be installed on the ends of all conduits. Where necessary conduit runs shall be uniformly graded so that water will drain out of the conduit.

Flexible conduit for expansion and deflection loops shall be provided at each expansion joint in bridge structures, and all other places as shown in the Drawings or where directed by the MEW/Engineer and shall provide at least the expansion and deflection expected in the structure joints that they span.

In the event of any discrepancy between the Electrical and the Structural Drawings in the routing of conduit or the mounting of luminaires and switches on structures, the Structural Drawings shall take precedence.

1406.02 CABLE TRAY

Cable tray be installed where exposed cables are to be routed within the hollow structure of bridges and viaducts, as shown on the Drawings. The cable tray shall be of mild steel with a return flange and shall be capable of carrying a uniformly distributed load of 50 kg/m with a deflection of less than 12 mm at mid span. The tray shall be fixed to supports, in positions approved by the MEW/Engineer, shall be free from burrs and sharp edges and shall be galvanised, after fabrication, to BS EN 10346:2009. On completion of fixing, any damage to the galvanising shall be painted over with a zinc rich paint to the approval of the MEW/Engineer.

Cables shall be installed at a distance between centers of one and half times the overall diameter of the larger cable.

1406.03 CABLE TRUNKING

Cable trunking shall be installed where cables are to be attached to the exterior surface of a structure, as indicated on the Drawings. The trunking shall be constructed and protected by galvanising in accordance with BS 4678 : Part 1 and IEC 61084-2-1. Dimensions other than the preferred sizes may be required.

Trunking shall be rigidly supported and secured to the structure in positions to be approved by the MEW/Engineer, and all bonds must allow the cables within them to comply with the minimum-bending radius recommended by the cable manufacturer. The construction of the trunking system shall allow the cables to be placed or drawn into position without risk of damage , and all removable covers shall be securely fixed after cabling is completed. Every entry to finished ducts or trunking shall either be so placed as to prevent the ingress of water, or be protected against such ingress.

1406.04 MEASUREMENT AND PAYMENT

1406.04.1 Method of Measurement and Basis of Payment

Cable trays, trunking and conduit shall each be measured separately stating the type and size. Measurement shall be by the meter run along the centerline of the cable tray, trunking or conduit without deduction for fitting and accessories.

Payment shall be at the rates inserted in the Bills of Quantities which rates shall include supply and installation of all materials and any accessories for the appropriate completion and to the satisfaction of the MEW/Engineer including couplings, various fittings, accessories and fixings.

1406.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1406.1	Cable tray … mm wide(type)	m
1406.2	Conduit …mm dia.(type)	m
1406.3	Trunking…x ... mm(type)	m

1407 - LIGHTING MASTS

1407.01 LIGHTING MASTS 25 MTO 40 M HIGH

This work shall consist of furnishing and installing the high lighting mast complete with shaft, luminaires, lowering mechanisms with supporting cable, power cable, luminaire mounting ring, head frame assembly and accessories and miscellaneous items such as circuit breakers, terminal boards, receptacles, necessary to provide a complete and working lighting unit.

25 m to 40 m high lighting mast units and all associated appurtenances (head frame, luminaire ring, winch, etc.) shall be designed manufactured and finished entirely as specified in these Specifications and in Technical Report No. 7 High Mast Lighting published by the Institution of Lighting Engineers (ILE), Regent House, Regent Place, Rugby, Warwickshire, UK, except as follows:

a. Add to Clause 2.7.1 of Specification for Masts and Foundations – Technical Report No. 7 " The composition of the steel shall comply with the limitations given in ASTM A385 Clause 3.2 such that when galvanised in accordance with Clause 2.11 a coating of uniform appearance and colour is obtained."

b. In Clause 2.11 of Report No. 7 "ASTM A123M and A385M" is to be substituted for "BS EN ISO 1461".

The steel used for fabrication shall comply with BS4360 and shall be equivalent to or better than grade 50B. The minimum tensile strength of the steel shall be 490N/mm² and the yield stress, 355N/mm². The lighting mast shall be capable of withstanding mean hourly wind speeds of 110km/hr, with a three second gust speed (V10) of 160km/hr when equipped with eight 1000W luminaires or ten 400W luminaires of the maximum weight and windage area.

The mast shall be circular or polygonal section as shown on Drawings, tapered steel tube with slip joints that can be mechanically fitted together in the field.

A maximum number of three sections shall be allowed for a mast up to 30.5 m in height, and four sections above this height.

Lighting masts shall be equipped with a head frame and luminaire ring system that can be lowered by a winch to within 1 m of the surface of the ground. The winch shall be powered by a portable heavy-duty reversing electric power unit.

Remote controls shall permit the operator to stand at least 5 m from the base of the mast. The winch assembly shall be designed to safely raise and lower the system equipped with the maximum weight of luminaires described previously.

The luminaires shall not be attached until after the masts have been erected.

A vandal resistant weatherproof door shall be provided near the base with a door opening of minimum size consistent with clear access to the equipment mounted therein. The opening shall be stiffened by a minimum 80mm wide and 10mm thick substantial steel frame all around, projected inside and out, and the door shall be fitted to the base compartments by a minimum of three, 80mm long, 2mm thick, high quality stainless steel hinges. The diameter of the hinge pins shall be a minimum of 5mm and the hinges shall be fitted to the main body of the mast and the door by a minimum of two M6 stainless steel bolts with two nuts and plain spring

washers. The center hinge shall be fixed in the opposite direction and the tails of the bolts deformed to make the doors and the bolts non-removable. Alternatively, the hinges may be from galvanized steel sheet, minimum 3mm thick. These shall be fixed by neatly welding all round to the satisfaction of the MEW/Engineer. An approved sealing gasket of silicone rubber shall be affixed to the door to render it dustproof. The distance from the mast base flange to the bottom of the door opening shall be a minimum of twice the width of the door opening. Vandal and corrosion resistant door locking devices shall be provided to the degree of protection provided by IP33 as per IEC 60529. The lock shall be of substantial design without any strips at the door opening and the keys shall be 8mm Allen keys for all openings.

All masts erected in the same line shall be positioned so that the doors on all of them face in the same direction. This direction shall be agreed with the MEW/Engineer before erection.

The lighting masts shall be connected to the substructure by means of a flange plate and holding down bolts (including lock-nuts). The connection shall be designed for the collapse limit state using the safety factors for loads and materials given in Clauses 2.4 and 2.5 respectively of ILE Technical Report no. 7.

The holding down bolts shall be installed with an anchor plate and a template to ensure correct vertical and horizontal bolt alignment. A suitably sized U-type ground terminal from minimum 3mm thick galvanized steel plate with one M10 bolt, nut, and washer shall be provided in a readily accessible position in the base compartment near the bottom of the door opening. A similar ground terminal shall also be provided for terminating the lightning protection conductor.

The complete mast unit and all its appurtenances shall be hot dip galvanised in accordance with the requirements of Technical Report No. 7 of the Institution of Lighting Engineers as modified herein and Section 12 (Metal Works) of these Specifications. The mean coating thickness of galvanizing shall be 85 microns as a minimum for all lighting high masts, luminaire ring assembly and foundation bolt frames.

The flange plate and parts intended to be in contact with the mast foundation shall be coated externally with black bituminous paint.

Anchor bolts for the lighting masts shall conform to the requirements of ASTM A307, ASTM F1554 Grade 55. The anchor bolts shall be capable of supporting the mast at the maximum bending moment for the particular light masts. Typical fabrication details are noted on the Drawings but mast manufacturer's recommendations may be substituted with the approval of the MEW/Engineer. Bolts and nuts are to be hot-dip galvanised in accordance with ASTM A153M or other such protection system used as may be approved by the MEW/Engineer.

The Contractor shall produce a certificate from a registered Structural engineer that the proposed lighting mast design meets the above requirements. He shall also produce, after manufacture, a notarised statement certifying that the mast and lowering device were built in accordance to the said design.

During shipment to the Site the masts shall be containerised. During storage on Site the masts shall be carefully protected to preserve the finish.

The sections shall be selected for matching appearance and shall be pre-fitted and match-marked in the factory.

The lighting mast shall be straight and centered on its longitudinal axis under no wind conditions so that, when examined with a transit from any direction, the deviation from the normal shall not exceed 3 mm within any 1.5 m of height.

The winch shall be totally enclosed and permanently lubricated and shall be of such design and gear ratio that the lowering can be accomplished within approximately 8 minutes from a height of 40 m. Open type or semi-enclosed type winches with canvas covers will not be accepted. All oil sealing gaskets and 'O' rings or seals of the winch shall be fully suitable for Kuwait's extreme temperature conditions and the manufacturer shall guarantee that the gaskets, 'O' rings and seals will not deteriorate, become damaged or cause any oil leakage for a minimum period of ten years. The design shall allow the winch to be installed, serviced and removed through the door opening .The winch shall be operated by a reversible electric motor or power tool unit which shall be powered from a 415/240 V weatherproof outlet or receptacle located in the service area of the mast. The electric power outlet for operating the winch shall be arranged so that it is impossible for the luminaires to be illuminated while they are being lowered or raised. The winch shall be self-sustaining and shall be fitted with an automatic locking device to prevent rotation in the "lower" direction when the mast is in service when non-grooved drums are used. One full layer of steel rope shall be retained on the drum when the carriage is lowered to ensure correct rope stacking.

The motor shall be capable of being installed at the service entrance and means shall be provided for its remote control from a distance of 5m. A torque limiter shall be furnished with the power tool unit.

A watertight power receptacle shall be provided on the luminaire ring to allow testing of the luminaires while in the lowered position.

The hoisting and power cable sheaves shall be made of stainless steel materials. The groove diameter of the sheaves shall be coordinated with the diameter of the stainless steel hoisting cables and the diameter of the power cable.

Two stainless steel aircraft cables or equivalent each with a safety factor no less than five times the safe working load (SWL) of the winch shall be provided.

The hoisting cables shall be identified and a test certificate shall be provided with each numbered set.

There shall be a head frame assembly attached to the mast top by means of a steel slip fitter and secured by a minimum of four stainless steel set-screws.

The head frame shall also include three latching devices to support the luminaire ring assembly when the lowering device is not in operation. Alternative design to hold the luminaire ring assembly under tension may be proposed subject to MEW's/Engineer's approval.

The system shall be provided with a circuit breaker of the rating indicated on the Drawings. There shall be a power disconnect receptacle in the mast base. The circuit breaker shall be suitably derated for Kuwait climatic conditions, such that no further derating will be required.

Means of discharging any accumulated moisture shall be provided at the mast base. When grout is used between the flange plate and the top of the foundation to seal it, provisions shall be made for adequate drainage. Grout shall be as specified in Section 5 (Concrete Works) of these Specifications.

The Contractor shall obtain from the manufacturer literature stating clearly the type of steel he proposes to use in manufacture of the lighting masts, the chemical and mechanical properties and all other information required in the Schedules contained in the Contract Documents.

The Contractor shall supply a sample length of mast, a minimum 1500 mm long, incorporating the proposed door opening complete with door, gasket, and locking device, showing any typical welds and being galvanised by the method proposed to be used for the permanent works.

The steel used for the sample shall be of the chemical composition proposed for the permanent works.

1407.02 PORTABLE POWER UNIT

This Clause pertains to portable power unit coupled with torque limiter, power unit mounting frame and remote control switch necessary to supply driving power to the winch assembly for raising and lowering the high mast luminaires.

The power unit shall be a portable, heavy duty, reversible electric motor, 1.1 kW, suitable for single phase or three phase operation, 50 Hz power supply. Part of the power unit shall be a remote control unit with sufficient power cable to permit the operator to stand 5 m away from the mast base during the lowering and raising operation. Average speed of raising and lowering the high mast luminaire assembly shall be approximately 5m/min.

Where hinged, fixed-head masts are offered, the power unit shall comprise twin double-acting hydraulic rams together with hydraulic pump and control equipment mounted on a transportable chassis which can easily be brought into position at the base of the mast. The pump shall be powered by a single phase or three phase 50 Hz electric motor of sufficient rating to enable the mast to be lowered within 4 minutes and raised within 8 minutes. The hydraulic circuit shall be designed to "fail safe" such that if any flexible hose connection becomes detached or severed, the mast will be lowered at a safe speed from any intermediate position. Full-flow, high capacity filters shall be provided to protect the system against accidental ingress of sand or other harmful particles whilst hose connections are detached.

Portable power unit shall be supplied by the Contractor to the MEW/Engineer on handover in the numbers listed in the Bills of Quantities.

1407.03 GUARANTEE

A guarantee certificate shall be submitted as required by Clause 1401.09 of these Specifications to guarantee that the designed life time of the offered lighting masts is minimum twenty-five (25) years, that the masts will give continuous trouble-free service at Kuwait's extreme temperature and climatic conditions and that any lighting mast including the base compartment door hinges that will fail or breakdown within a period of twenty-five (25) years from the date of commissioning of the project will be repaired or replaced and reinstalled free of charge.

A guarantee certificate shall also be submitted to guarantee that the raising and lowering device of the lighting masts will give continuous trouble-free service at Kuwait's extreme temperature and climatic conditions and that any device that will fail or breakdown within a period of ten (10) years from the date of commissioning of the project will be repaired or replaced and reinstalled free of charge.

1407.04 MEASUREMENT AND PAYMENT

1407.04.1 Method of Measurement and Basis of Payment

Lighting masts shall each be enumerated stating the height, luminaire array and size and type of lamps, as per Drawings and Schedules.

Supply of portable power units shall be enumerated.

Payment at the rates shown in the Bills of Quantities shall be full compensation for furnishing all required materials, assembly and installation, including mast, luminaires and lamps,respective control gears, service cutouts, reinforced concrete foundations, anchor bolts, incoming and outgoing ducts and cabling inside mast, testing, checking performances and all incidental works and components as specified or required to provide a complete approved installation.

Payment rate for portable power units shall be at the rate inserted in the Bills of Quantities for each unit supplied.

1407.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1407.1	Lighting mast (height) (nr.of luminaires on ring) (type and wattage) (ref. drwg)	nr
1407.2	Portable power unit	nr

1408 - LIGHTING COLUMNS 16 m AND 22 m HIGH

1408.01 GENERAL

The 16 m and 22 m lighting columns shall be suitable for supporting an array of 2, 3, 4, or 6 No. luminaires mounted on specially made brackets as shown and described in details on Drawings.

The columns are to be erected so that the doors on all of them face in the same direction. The direction shall be agreed with the MEW/Engineer before erection.

The luminaires and control gears shall be supplied as under the different Clauses of these Specifications.

The columns shall be 16 m or 22 m in height above ground level, inclusive of breakaway transformer base where applicable, of high strength structural steel, hot dip galvanized, conical in shape, circular in cross section, having a spigot at the top and substantial flange plate at the bottom with a foundation-bolt-frame.

The 16 m and 22 m columns shall be complete in all respects and no welding shall be required on site at the time of erection.

The bracket projections of all lighting columns shall be 600 mm in length..

The Contractor shall supply a sample length of lighting column, a minimum of 1500 mm long, incorporating the proposed door opening complete with hinged door, gasket, and locking device, showing a typical weld and being galvanised by the method proposed to be used for the permanent works.

The steel used for the sample shall be of the chemical composition proposed for the permanent works.

1408.02 DIMENSIONS

Column dimensions shall be as shown on the Drawings.

1408.03 GENERAL REQUIREMENTS FOR 16 m AND 22 m COLUMNS

The lighting columns shall be designed in accordance with AASHTO Standard Specifications for Structural supports for Highway Signs, Luminaires and Traffic Signs. The steel used for fabrication shall comply with BS4360 and shall be equivalent to or better than grade 50B. The minimum tensile strength of the steel shall be 490N/mm² and the yield stress, 355N/mm². The Lighting columns shall be capable of withstanding mean hourly wind speeds of 110 km/hr with a 3 second gust speed of 160 km/hr. The column thickness shall be as indicated in the technical submittal schedules and as shown on the Drawings.

Verified by design calculations, thickness shall be such as to comply with the requirements for a compact tube given in the above AASHTO Specification. The columns shall be designed assuming that they are fully equipped with the maximum number of luminaires specified herein, with each item being of the maximum weight and windage area, and taking into account all structural aspects including door openings.

The columns shall have two base compartments with vandal resistant weatherproof doors for housing the control gear panels and a service cut-out. Each door opening shall be stiffened by a steel frame continuously welded all around. For Motorway/Expressway lighting systems the frames shall be projected inside and outside and for local roadway lighting systems, these shall be flush or overlapping type, all as shown on the Drawings. The top of the upper door opening shall be a maximum of 2 m (for rigid columns) or 1.6 m (for breakaway columns) above the bottom of the flange plate. The bottom of the lower door opening shall be a minimum of 0.5 m (rigid columns) or 0.18 m (breakaway columns) above the bottom of the flange plate. One single larger dimensioned base compartment for 22m lighting columns can also be providd subject to the approval of MEW/Engineer.

The flange plate thickness of the 16m and 22m. lighting columns shall be 40 mm and 50mm respectively and the flange plate shall be continuously welded to the column from inside and outside in an approved manner and gusset plates are required to be provided . The size of the gusset plates shall be 180 mm x 90 mm x 10 mm (Th.) for 16 m lighting columns, which shall be continuously welded to the body of the column and the flange plate. Adequate number of suitably sized gusset plates shall be provided and continuously welded for 22m lighting columns. The manufacturer's name, Contract No. and date of manufacture shall be marked at the front side of the flange plates with minimum 1 mm. deep engraving or punching.

The base compartments doors shall be provided all around with high heat resistant silicon rubber gaskets having a minimum thickness of 4 mm.for weather-proofing to comply with the protection category of minimum IP 33 to IEC:60529. The galvanized steel hinges shall be minimum 3mm. thick and 3 Nos. of 80 mm. long hinges shall be provided for each door. The diameter of the hinge pin shall be minimum 5 mm. and the hinge leaves shall be continuously welded all around to the body of the column and the door in an aesthetic manner subject to the MEW/Engineer's approval. The centre hinge shall be reversed to make the doors non-removable.

Stainless steel hinges may be considered by the MEW/Engineer provided they are of a very high quality and the Contractor is ready to submit a guarantee stating that the hinges will not corrode in 25 (twenty-five) years time and if any corrosion occurs within this period they will replace and re-fix all hinges at no extra cost whatsoever.

The stainless steel hinges shall be of the same dimensions and thickness as stated above for the galvanized steel hinge and shall be fitted to the body of the column and the door by at least 2 Nos. high quality stainless hexagonal socket head steel bolts, two lock nuts and necessary plain and spring washers.

A suitably sized U-type ground terminal from 3mm thick galvanized steel plate with one stainless steel M10 bolt, nut, and washers shall be provided on the inside of the shaft in a readily accessible position in the base compartment near the bottom of the door opening.

The array of luminaires or a particular lighting unit on a circuit shall be connected in R-Y-B phase sequence in order to balance the electrical load as close as possible over the three phases.

The outgoing power supply cable of the types and sizes from the control cabinet/feeder pillar as shown in the Contract Drawings shall be looped in / looped out at each lighting column through a service cut-out of the rating as specified and/or indicated in the Drawings.

Wiring between the cut-out and the control gear panels shall be Type-TI3 PVC insulated 5 core or 4 core with a separate earth wire 90° C conductor temperature. Cable shall be at least 4 mm² copper conductor.

Wiring between the control gear panels and each luminaire shall be Type-TI3 PVC insulated 3-core 2.5 mm² copper conductor flexible cables.

Steel straps/brackets provided for fixing hanging gear panels and service cut out shall be welded inside the base compartment. Exact locations and dimension of the steel straps shall be as indicated in the Standard Drawings and approved shop drawings by the MEW/ Engineer at the proper time before fabrication.

The door of the base compartment shall be fixed with a substantial locking device. The locking device shall be of a type that opens with an 8 mm Allen Key. The Contractor shall provide 8 No. keys for the locking device. All loose parts of the locking device shall be so arranged that they are held captive on the door when it is in the open position. All the moving parts of the locking device shall be nickel plated. Precaution shall be taken to prevent the door being pushed into the column during transit.

The column shall not have more than two sections other than the bracket.

Any minor modifications or additions, which in the opinion of the MEW/Engineer are essential to the construction of the column shall be carried out without any additional cost whatsoever.

During shipment to the Site the columns shall be containerized. During storage on Site the columns shall be carefully protected to preserve the finish.

The exterior surfaces of the column shall be free from protuberances, dents, cracks or other imperfections.

The column and vertical part of the arm bracket shall be constructed straight. The angle of elevation of the straight bracket arms above the horizontal shall be stated by the Contractor in his submission of Schedules and Technical Details (Clause 1401.09) and shall be limited to 5°, 10°, 15° or 20° . Other angles will not be acceptable.

Suitable tests shall be made on random samples to ensure the above requirements are met. Facilities for such tests shall be provided by the Contractor.

The Contractor shall obtain from the manufacturer literature stating clearly the type of steel he proposes to use in manufacture of the light columns, the chemical and mechanical properties and all other information required in the Schedules contained in the Contract Documents.

The complete column and appurtenances shall be hot dip galvanized in accordance with BS EN ISO 1461 and Section 12 (Metal Works) of these Specifications. The composition of the steel shall comply with the limitations given in ASTM A385 Clause 3.2 such that when galvanized a coating of uniform appearance and color is obtained. The mean coating thickness of galvanizing shall be 85 microns as a minimum for all lighting columns, brackets and foundation bolt frames.

The flange plate where in contact with the column foundation shall be coated externally with black bituminous paint. Where the flange plate is in contact with a breakaway transformer base the contacting surfaces shall be thoroughly coated with aluminium impregnated caulking compound, or a synthetic rubber gasket may be placed between the two surfaces, as approved by the MEW/Engineer.

Means of discharging any accumulated moisture shall be provided at the column base. When grout is used between the flange plate and the top of the foundation to seal it, provision shall be made for adequate drainage . Grout shall be as specified in Section 5 (Concrete Works) of these Specifications.

All the accessories of the lighting columns shall be greased or enclosed with an alternate approved protection and packed before delivery.

1408.04 BREAKAWAY BASE/COLUMN COMBINATION- 16M BREAKAWAY COLUMNS

Unless otherwise indicated on the Drawings, 16 m lighting columns shall incorporate a cast aluminium breakaway transformer base and electrical breakaway quick disconnect. The base shall be constructed so that when used with the size and weight of column proposed, the assembly shall meet the requirements of AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

The transformer base and column combination shall be such as to withstand the wind loads described in Clause 1408.03 herein.

Electrical breakaway quick disconnects are to be provided as indicated on the Drawings.

1408.05 GUARANTEE

A guarantee certificate shall be submitted as required by Clause 1401.09 of these Specifications to guarantee that the designed life time of the offered lighting columns is minimum twenty-five (25) years, that the columns will give continuous trouble-free service at Kuwait's extreme temperature and climatic conditions and that any lighting column including the base compartment door hinges that will fail or breakdown within a period of twenty-five (25) years from the date of commissioning of the project will be repaired or replaced and reinstalled free of charge.

1408.06 MEASUREMENT AND PAYMENT

1408.06.1 Method of Measurement and Basis of Payment

Lighting columns shall each be enumerated stating the type and height, number and type of luminaires in array and type and rating of lamps, as per Drawings and Schedules.

Breakaway light columns and hinged light columns shall each be so described and enumerated stating the type and height of column (16m), number and type of luminaires, type and rating of lamps.

Lighting columns or any other item of associated equipment to be re-used from the existing lighting system shall be so described in detail and enumerated.

Payment at the rates shown in the Bills of Quantities shall be full compensation for furnishing all required materials, including column, luminaires and lamps, brackets, assembly and installation, reinforced concrete foundations, anchor bolts, incoming and outgoing ducts, cabling inside column, terminal devices and circuit breaker (cutouts), control gear, earthing, and the provision or reinstallation (as appropriate) of breakers, transformer bases, electrical breakaway disconnects, incoming cable and T-joints connection to power supply, testing, checking performance, and all incidental works and components as specified or required to provide a complete approved installation as per the Specifications and Contract Conditions.

1408.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1408.1	Lighting column (22m) (nr.of luminaires) (type and wattage) (ref. drwg)	nr
1408.2	Lighting column (16m) (nr.of luminaires) (type and wattage) (ref. drwg)	nr
1408.3	Breakaway lighting column (16m) (nr.of luminaires) (type and wattage) (ref. drwg)	nr
1408.4	Hinged lighting column (16m) (nr.of luminaires) (type and wattage) (ref. drwg)	nr

1409 - LIGHTING COLUMNS, 6m, 8m, 10m AND 12m HIGH

1409.01 GENERAL

These columns shall be suitable for supporting a number of luminaires as described in Clauses 1411.02.1 to 1411.05.1 of these Specifications; the required configuration and length of bracket arms are to be as described in the Contract Documents and /or shown on the Drawings.

The luminaires and control-gear are to be supplied as required under different clauses of these Specifications.

The columns shall be 6, 8, 10 or 12 metres in length, inclusive of breakaway transformer base where applicable, and of high strength structural steel, hot dip galvanized, one piece, conical in shape, circular in cross section, having a spigot at the top and substantial flange plate at the bottom with a foundation-bolt-frame.The columns shall be complete in all respects and no welding shall be required at the Site at the time of erection.The columns are to be erected so that the doors on all of them face in the same direction. The direction shall be agreed with the MEW/Engineer before erection.

The Contractor shall supply a sample length of lighting column, a minimum 1500 mm long, incorporating the proposed door opening complete with hinged door, gasket and locking device, showing a typical weld and being galvanized by the method proposed to be used for the permanent works. The steel used for the sample shall be of the chemical composition proposed for the permanent works.

1409.02 DIMENSIONS

Column dimensions shall be as shown on the Drawings.

1409.03 GENERAL REQUIREMENTS FOR 6m, 8m, 10m AND 12m COLUMNS

The 6m, 8m, 10m and 12m column specification shall meet the requirements and conditions given above in Clause 1408.03 for 16m and 22m columns except as specified here below.

The Lighting columns shall be capable of withstanding mean hourly wind speeds of 110 km/hr with a 3 second gust speed of 135 km/hr. Lighting column thickness shall be as indicated in the technical submittal schedules and as shown on the Drawings which shall be verified by calculations with minimum tensile and yield strengths.

The column shall not have more than one section other than the bracket.

The flange plate thickness of the 8m, 10m and 12m lighting columns shall be 30 mm.and the same for 6 m. columns 20 mm. The flange plate shall be continuously welded to the column from inside and outside in an approved manner and four (4) Nos. of gusset plates shall be provided. The size of the gusset plates shall be 150 mm x 90 m x 10 mm. (Th.) for 12 & 10 metres and 130 mm x 80 mm x 8 mm. (Th.) for 6 and 8 m lighting columns, which shall be continuously welded to the body of the column and the flange plate.

Wiring between the control gear panels and each luminaire shall be Type-TI3 PVC insulated 3-core 1.5 mm² copper conductor flexible cables.

1409.04 HINGED STEEL LIGHTING COLUMNS 6m, 8m, 10m AND 12m HIGH

Hinged lighting Columns shall be provided where shown on the Drawings. The hinge shall be located in an “over-centre” position so as to allow the lighting unit to be lowered to a maximum of 170 degrees from its operational position. The nature and position of the hinge shall ensure stability in the working position and when lowered for maintenance purposes.

During lowering operations, or when fully lowered, no part of the light column or lighting unit shall be higher than the specified mounting height of the light column concerned. The lowering shall take place in a plane parallel to the road centre line unless otherwise agreed in writing with the MEW/Engineer.

The hinging device shall operate freely allowing for the lighting units to be raised or lowered in complete safety by one man without undue physical efforts and without any mechanical or hydraulic assistance.

The design shall be such that it ensures there can be no detrimental effects on the luminaires, lamps, associated control-gear or electrical connections as a result of raising or lowering operations.

The operation of the hinged light columns shall be on the principal of the balance i.e. the weight of the lighting unit shall be counter–balanced by the weight of the lower section itself or by additional weights to be provided by the manufacturer.

Control of raising and lowering operations shall be by means of a "slip-on" rope attachment. The locking device shall be of the all-metal "tamper-proof" type. The light column shall remain in the upright position even if the device is unlocked, so as to ensure a reasonably "fail-safe" arrangement. An alternative hydraulic system may be substituted with the approval of the MEW/Engineer.

Warning Notices in Arabic and English shall be affixed to both sides of the columns. These shall comprise a red danger triangle with lightning flash in black and the words.

DANGER – MAINTENANCE FROM GROUND LEVEL ONLY

The Contractor shall submit for approval full details of such signs including the method of fixing. The signs shall, when fixed to the columns, cause no conflict with the operation of raising and lowering of the light unit.

Electrical control gear may be located in the luminaire housing subject to the approval of the MEW/Engineer.

Lighting columns provided with hinged joints shall, unless otherwise indicated in this Clause or on the Drawings, comply with the requirements of the Specifications in all relevant respects and full details and design calculations are to be submitted in accordance with such requirements.

1409.05 BREAKAWAY BASE/ COLUMN COMBINATION

Unless otherwise indicated on the Drawings, 6m, 8m, 10m and 12m lighting columns shall incorporate a cast aluminium breakaway transformer base and electrical breakaway quick-disconnect. The base shall be constructed so that when used with the size and weight of column proposed, the assembly shall meet the requirements of AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

The transformer base and column combination shall be such as to withstand the windloads described in Clause 1409.03 herein.

Electrical breakaway quick disconnects are to be provided as indicated on the Drawings.

1409.06 GUARANTEE

A guarantee certificate shall be submitted as required by Clause 1401.09 of these Secifications to guarantee that the designed life time of the offered lighting columns is minimum twenty-five (25) years, that the columns will give continuous trouble-free service at Kuwait's extreme temperature and climatic conditions and that any lighting column including the base compartment door hinges that will fail or breakdown within a period of twenty-five (25) years from the date of commissioning of the project will be repaired or replaced and reinstalled free of charge.

1409.07 MEASUREMENT AND PAYMENT

1409.07.1 Method of Measurement and Basis of Payment

Lighting columns (6m, 8m, 10m and 12m) shall each be enumerated stating the height, flange base, luminaire or number of luminaires in lighting unit and type, size and type of lamps, as per Drawings and Schedules.

Breakaway light columns and hinged light columns shall each be so described and enumerated, stating height, luminaire or number of luminaires in lighting unit, size and type of lamps, as per Drawings and Schedules.

Lighting columns and any other item of associated equipment to be re-used from the existing lighting system shall be so described and enumerated .

Payment at the rates shown in the Bills of Quantities shall be full compensation for furnishing all required materials, including column, luminaire(s) and lamps, assembly and installation, reinforced concrete foundations, anchor bolts, incoming and outgoing ducts, cabling inside column, terminal devices and cutouts, and the provision or reinstallation (as appropriate) of breakaway transformer bases, electrical breakaway, disconnects,

incoming cable and T-joint connection to power supply, testing, checking performances and all incidental works and components as specified or required to provide a complete approved installation as specified.

1409.07.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1409.1	Lighting column (12m) (10m) (8m) (6m) (nr.of luminaires) (type and wattage) (ref. drwgs and schedule)	nr
1409.2	Breakaway Lighting column (12m) (10m) (8m) (6m) (nr. of luminaires) (type and wattage) (ref. drwgs and schedule)	nr
1409.3	Hinged Lighting column (12m) (10m) (8m) (6m) (nr.of luminaires) (type and wattage) (ref. drwg)	nr

1410 – LUMINAIRES FOR 25 m TO 40 m MOUNTING HEIGHT

1410.01 GENERAL REQUIREMENTS

Luminaires shall provide a light distribution equivalent or superior to requirements of IEC 60598-1, BS EN IEC 60598-2-3, cut-off specification , and shall be mechanically strong and easy to maintain. The luminaires when installed shall be of adequate design to operate at a mounting height of up to 40 m and withstand a wind speed of 110 km/h (160km/h gusts).

The luminaire shall be designed and manufactured entirely as specified in Section 4 of ILE Technical Report No.7 or superior specification, and the ballast, components, socket reflector, mounting adjustment, fuse and wiring terminals shall be readily accessible for servicing. The luminaire shall be provided with a levelling surface and clearly calibrated means of adjustment for orientation, the settings of which shall not be prone to alteration during re-lamping and cleaning operations. The luminaires shall have a pipe arm barrier to limit the amount of insertion. The terminal board shall be equipped with pressure terminal connectors. A luminaire providing a semi cut-off type of distribution will be considered as an alternative, provided that the performance of the complete lighting system complies with Clause 1412.01 of these Specifications, and in particular that glare is strictly controlled.

The luminaire body shall be made from a single piece aluminium light alloy casting from LM6 or better grade of material and shall have a minimum thickness of 2mm. The aluminium alloy shall be highly resistant to corrosion and additional protection using paint or powder coat shall be applied if necessary. If not forming part of the luminaire body, the control gear and spigot compartment shall be fitted to the luminaire with an adequate number of substantially-sized bolts and nuts.

The reflectors shall be one piece high purity polished anodized aluminium reflectors having a minimum thickness of one (1) millimetre.

Additionally, the luminaires when trained to obtain the specified illumination shall be firmly locked in position and it shall not be possible to inadvertently relocate fittings during maintenance operations.

The transparent cover shall be made of crystal clear, heat resistant, impact-resistant, tempered glass bowl or a glass dish of crystal-clear and heat–resistant boro-silicate glass of a minimum thickness of 5mm. Covers made from plastic, acrylic or polycarbonate materials are not acceptable. The cover hinges, latches, nuts screws, washers, pins and other parts shall be made of substantial (heavy duty) stainless steel and the cover shall be so hinged that the luminaire may be safely opened for maintenance purposes without danger of the cover falling to the ground. . The mechanical and chemical properties of the material of the glass cover shall be submitted for approval. The glass cover shall be encased in die cast aluminium alloy frame and be secured substantially with adequate number of stainless steel clips or supports

The lamp socket shall be mogul screw type, heavy duty porcelain enclosed, adjustable for varying candle-power angles and equipped with suitable means for limiting lamp vibration. The housing and refractor holder shall be made of aluminium or stainless steel. The external metal parts shall be finished to resemble polished aluminium or stainless steel. Alloys that darken due to atmospheric exposure shall be finished by painting grey or other

approved colour with a suitable lacquer enamel or other paint in accordance with Section 12 (Metal Works) of these Specifications. The terminals of all ballasts, capacitors and control gears shall be shrouded.

Luminaires on high masts which are situated in residential areas shall be provided with internal shields, screens or louvers as necessary to minimize light spill in the direction of residential property.

The luminaire shall have protection against the ingress of dust by means of a breathing filter in the luminaire body and moisture to degree IP65 of IEC60529 under all operating conditions The seal between the transparent cover and the housing shall be adequate to maintain this degree of protection.

Cable connections to the lampholder within the luminaire shall be of the heat resistant type with silicon , glass fibre or other approved insulation.

All luminaires shall be provided with a metal nameplate from a corrosion-resistant material in a position where it can be easily seen , distinctly and durably marked with the information specified in IEC 60598. Additionally, the manufacturer's name shall be marked on the luminaire body by engraving or by raised letters of a minimum10mm letter height. . All luminaires must have a Serial No. also engraved in minimum 5 mm. height letters and digits. The Serial No. shall be started with the Contract No. & Wattage of the lamp, after that with letters "S" and "C or S" for Sodium lamp and "Cut-off' or "Semi Cut-off' distribution and then with the Serial No. (e.g., RA123-400/250SC00001). Without the Serial Nos., the luminaire will be rejected.

1410.02 CONTROL GEAR

The control gear shall form an integral part of the luminaire installed in a separate compartment attached to it, and be designed to operate the lamp at the power rating shown. It shall be able to start the lamp and control it continuously for ambient temperatures ranging from –15˚ C to + 55˚ C. It shall be suitable for 50Hz, 240 V AC +/- 10% operation and shall regulate the output power to 12% of this input voltage. It shall operate the lamp without adversely affecting the lamp life and performance as specified herein with an overall power factor of at least 0.9 when operated under rated lamp load.

The ballast shall either be of the auto–regulator or the tapped type fully compatible with the lamp operation circuit and shall be suitable for satisfactory operation within a supply voltage range of 210 V to 250 V. Tapped type ballasts shall have terminals to accept 220 V and 240 V supply. Each terminal shall be brought out to a separate shrouded termination. Multi-lamp gear or ballasts operating more than one lamp shall not be employed. The ballast shall be independent single lamp type, encapsulated in an approved resin compound and be totally enclosed except where it is an auto-regulator type, which may be approved by the MEW/Engineer when it is sealed in a fully weatherproof compartment. The ballast shall be tropicalized and shall generally meet the thermal classifications and other safety and performance requirements as specified in IEC 60923, or an acceptable equivalent international standard. The average life at the site conditions specified shall be guaranteed as ten years minimum.

The capacitor shall be of the diphenyl impregnated type and shall be in a leak proof aluminium container fitted with a termination cap and a discharge resistor. Use of soldered connections will not be permitted. The use of a dry film type using metallised polypropylene film will be considered by the MEW/Engineer. The permitted operating temperature of the capacitor shall be marked on its case. The capacitors shall have values sufficient to raise the power factor to 0.9 or better. Each lamp shall operate using only one ballast and one capacitor. Any combination of two or more capacitors having the equivalent value of capacitance will not be accepted. The capacitors shall comply fully with IEC 61048 and 61049 or an equally acceptable international standard. The terminals of the capacitors shall be screw-less terminals with push wire connectors suitable for use with insulated bootlace ferrules.

The ignitor shall be electronic solid state from superimposed type and shall be arranged so that the ignitor circuit stops working after the lamp has started. It shall be totally enclosed.

The circuit shall include a shunt capacitor to isolate the mains from high frequency start pulses; this capacitor may also be used for power factor correction. The length of wiring between the ignitor and the lamp shall not exceed that recommended by the manufacturer for satisfactory lamp ignition and re-ignition of an extinguished lamp.

1410.03 1000 WATT METAL HALIDE LAMPS

The lamps shall comply with the following specifications and requirements:

a. Power into lamps : 1000 watts
b. Totals luminous flux : 90,000 lumens
c. Average life to burn out to exceed : 12,000 hours
d. At half-life, the maintained luminous flux shall be a minimum of 75% of the initial luminous flux.

1410.04 1000 WATT HIGH PRESSURE SODIUM LAMPS

The lamps shall comply with the following specifications and requirements:

a. Power into lamp: 1000 watts
b. Total luminous flux (after 100 hours): 130,000 lumens
c. Average life to burn out is to exceed: 12,000 hours
d. At half-life, the maintained luminous flux shall be a minimum of 75% of the initial luminous flux.

1410.05 GUARANTEE

A guarantee certificate shall be submitted as required by Clause 1401.09 of these Specifications to guarantee that the offered luminaires including all parts and components therein will give continuous trouble-free service at Kuwait's extreme temperature and climatic conditions and that any luminaire and/or any of its parts or components that will fail, breakdown, burn out or mal-function within a period of five (5) years from the date of commissioning of the project will be repaired or replaced and reinstalled free of charge.

A guarantee certificate shall also be submitted to guarantee that any lamp that will fail or burn out within a period of two (2) years from the date of commissioning of the project will be replaced and reinstalled free of charge.

1410.06 MEASUREMENT AND PAYMENT

1410.06.1 Method of Measurement and Basis of Payment

Payment for luminaires shall be included with the respective rate for lighting column/mast item in the Bills of Quantities, which includes lamps, control gear, support bracket, and all related necessary fittings.

Payment rate shall include inspection and testing of luminaires, as specified in Clause 1416 Of these Specifications

1411 - LUMINAIRES FOR 6 M TO 22 M MOUNTING HEIGHT

1411.01 600 WATT HIGH PRESSURE SODIUM STREET LIGHTING CUT-OFF LUMINAIRES

1411.01.1 General Requirements

The 600 Watt high pressure sodium cut-off luminaires shall be designed to operate on 240 Volts, single phase, 50 Hz., supply and to accommodate a 600 watt high pressure sodium lamp, tubular in shape with (E40) cap. The luminaire shall be equipped with an ignitor suitable for 600 watt high pressure sodium lamp and must be complete with all internal wiring.

The luminaire shall provide a "cut-off" distribution fully in accordance with the relevant IEC,BS,CIE and/or IESNA specification.

The luminaires shall be aesthetic in design and shape, from a modern concept, and shall have a degree of protection, minimum IP65 to IEC 60529 against the ingress of dust and moisture under all operating conditions. The control gear compartment shall have a degree of protection of minimum IP53.

The nominal overall dimensions for a 600 watt rated luminaire shall be 850 mm (L) x 375 mm (W). Acceptance of any minor tolerances in the overall dimensions of the luminaire is at the sole discretion of the MEW/Engineer.

The luminaires shall have their main body and other parts like frame for glass cover, top canopy, etc., pressure die cast from high grade aluminium alloy of minimum thickness 2.0 mm .

The luminaires shall be designed for lamp replacement from the backside with the use of a lamp holder cassette and a locking unit. Such components shall preferably be from non-corrosive metal fabrications. However, components made of high quality and high temperature resistant plastic materials may be considered provided such materials are guaranteed for a period of ten (10) years against any deformation and damage, but again. is at the sole discretion of the MEW/Engineer and may be rejected also. Fully detailed material specifications and test certificates of the plastic shall be provided. Without the details and test certificates the luminaire may be rejected. The lamp holder cassette shall have a collar all around and fitted to the reflector by high temperature resistant silicon paste and by rivets in at least three or four equidistant points. Full material specifications of the silicon paste shall also be submitted. Use of gasket for the cassette holder is not acceptable.

The aluminium alloy used for the luminaire body shall be highly resistant to corrosion and further protection shall be obtained by the application of primer and epoxy polyester paint by dry painting (powder coating) method in Grey or other approved colour. Fully detailed material specifications of the aluminium alloy and its grade shall be provided and indicated on the drawing. The material specifications for primer and epoxy paint shall also be submitted. Without the details the luminaire may be rejected.

The side entry mounting of the luminaire shall be suitable for fixing to column spigots having an outside diameter of 60mm and length not less than 120mm, which should be gripped by at least two to three number of galvanized or stainless steel hexagonal socket-head bolts suitable for Allen keys.

Control of the light flux shall be by means of single piece high purity polished anodized aluminium reflector of minimum thickness 1mm. The lamp shall be operated in a maximum of 20 degrees inclination above horizontal.

The cover of the lumnaire shall be clear, high heat and shock resistant, tempered glass bowl or a glass dish from a minimum thickness of 4 mm and the optical assembly of the luminaire shall be totally sealed without the use of any gaskets. The glass cover shall be encased in die cast aluminium alloy frame and be secured substantially with adequate numbers of stainless steel clips or supports. The cover frame shall be fitted to the body with substantial stainless steel hinges and catches. Covers made from polycarbonate or acrylic materials are not accepted.

The cover and the frame shall be so constructed, that when properly erected, no water can penetrate to the interior , when such penetration may cause deterioration of the wiring, lamp or luminaire. Internal surfaces shall be so designed as to avoid condensate falling on the lamp bulb.

Luminaires shall be so constructed that light directing equipment can be initially fitted or replaced only in the correct orientation to the light source.

The control gear housing shall be provided with an adequately dimensioned mounting plate for mounting the control gears inside as and where necessary.

All hinges, catches and pivots shall be of stainless steel, robust in section, and capable of simple operation without the use of special tools.

The luminaire shall also be so constructed that the temperature in any part shall not rise to a value, which will cause undue deterioration of the lamp, luminaire or internal wiring.

The luminaire shall also be so designed that there shall be no chilling effect on the neck of the lamp bulb arising from close proximity of the metal, or from draughts of cold air. All cables used for internal wiring shall be silicon rubber flexible of adequate size.

The lamp holder shall be from high temperature material and all its edges shall be smooth and free from any irregularities. The details of material specification of the lamp holder, the country of origin, manufacturer’s original leaflets/catalogues and a sample lamp holder shall be submitted to the MEW/Engineer for approval. Manufacturer’s name and country of origin must be engraved on the body or at the bottom of the lamp holder.

Gaskets when used for the control gear housing shall be silicon rubber gaskets and shall be capable of withstanding the temperature , radiation, moisture and other conditions to which they may be exposed, and to exclude dust, water, etc. to maintain the degree of protection specified. They shall be attached to the luminaire or luminaire part in such a manner that they will be retained in position when the luminaire is opened for maintenance.

Terminals shall be of non corrodible type, high temperature resistant and shall be easily accessible. If terminals are of the hole type with pinching screw, they shall have an adequate length of thread so that the screw may be turned beyond the clear position without being lost. The terminals shall be from polycarbonate or polyamide material.

All terminals of the luminaire shall be clearly and indelibly marked and a substantial earth terminal shall also be provided inside the luminaire.

All screws shall be as large as are reasonably practicable and all nuts shall be provided with lock washers.

All luminaires shall be provided with a non-corrosive metal name plate fixed with rivets in a position where it can be easily seen, distinctly engraved with the information as specificed in IEC 60598. All luminaires must have a Serial No., also engraved in minimum 5mm height letters and digits. The Serial No. shall be started with the Contract No.,wattage of the lamp, after that with letters “S” and “C” for Sodium lamp and Cut-off distribution and then with the Serial No. (e.g. RA123-600w-SC00001). Without the Serial No. ,the luminaire will be rejected.

Additionally, the manufacturer’s name shall be marked on the luminaire body either by engraving or raised letters of minimum 10mm height.

The luminaires and lighting columns, shall be configured and arranged as follows:

a. 2 Nos. 600 Watt high pressure sodium luminaires on a common bracket mounted on one side of a 22 m column
b. 4 Nos. 600 Watt high-pressure sodium luminaires mounted on a 22 m column. These shall be arranged in two pairs, displaced by 180^{o}.
c. 3 Nos. 600 Watt high pressure sodium luminaires on a common bracket mounted on one side of a 22m column.
d. 6 Nos. 600 Watt high-pressure sodium luminaires mounted on a 22 m column. These shall be arranged in two groups of three, displaced by 180 ^{o}.

1411.01.2 600 Watt HPS Lamp

The 600 W High Pressure Sodium Lamps shall be manufactured to the European standard practice. The lamps shall comply with the lEC Publication No. 60662 and IEC 62035 for safety, and shall be fully suitable for operation in conjunction with ballasts having operating characteristics as specified in this lEC, and/or lEC Publication No. 60923 except that the rated voltage shall be 240 volts instead of 220 volts. The lamps shall be tubular in shape with E-40 cap and clear type. The HPS lamps shall operate in conjunction with an external ignitor; lamps with built-in ignitors will not be accepted. Lamp sources shall not be exchangeable for the same luminaire considered.

The 240 volts supply voltage can vary up to plus or minus six percent (+/-6%) and the lamp manufacturer has to guarantee that this will not detrimentally affect the lamp life and overall performance.

The average rated life or the life expectancy of the lamps shall be considered as the number of burning hours at 10 hours/start which have elapsed when 50 (fifty) per cent of lamps from a large batch have failed.

Lamp characteristics shall be as follows:

a. Power into lamp: 600 watts
b. Total luminous flux (after 100 hours): 90,000 lumens
c. Average life to burn out to exceed: 16,000 hours
d. At half life, the maintained luminous flux shall be minimum of 75% of the initial luminous flux.

1411.01.3 Control Gear

The control gear associated with the HPS luminaires shall consist of dual power dimming ballasts, capacitors, and ignitors required for starting and running the high pressure sodium lamps.

1411.01.3.1 Dual Power Dimming Ballast

The dual power dimming ballasts shall be fully in accordance with the IEC Publication Nos. 61347 and 60923 in regard to the general, safety and performance requirements, and shall be resin encapsulated. independent type and single lamp ballasts for installing in the base compartments of street lighting columns. The ballasts shall operate on 240 volts, 1-phase, 50Hz supply.

The dual power dimming ballasts shall be designed in order that the lumens output of the lamps can be reduced from 100% to 50% at a pre-set time during the night through a power switching device operated centrally and automatically by an astronomical time switch installed at the street lighting control cabinet/feeder pillar, thus to achieve a saving of energy by approximately 35% to 40%.

The ballast shall be encased in polyester or other suitable impregnant that are fully suitable for use in the climatic conditions of the Site. The resin embedding process shall ensure satisfactory encapsulation and efficient level of insulation. It is envisaged that the insulation materials employed would guarantee prolonged and trouble-free service. The coil winding shall preferably be of Class “C” insulation and formers shall be of Class “H” insulation.

The ballast shall be tropicalised and shall meet the thermal classifications and requirements of Independent Ballast as specified in IEC 60923. The average life at the service conditions specified shall be guaranteed 10 years minimum.

1411.01.3.2 Capacitors

The power factor correction capacitors shall fully comply with IEC 61048 and IEC 61049.

The capacitor shall be the diphenyl impregnated type and shall be in a leak-proof aluminium container fitted with a terminal cap and discharge resistor. Use of soldered connections will not be permitted. The use of a dry film type using metallised polypropylene film will be considered by the MEW/Engineer. The permitted operating temperature of the capacitor shall be marked on its case. The capacitors shall have a value sufficient to raise the power factor to 0.9 or better. Each lamp shall operate using only one ballast and one capacitor. Any combination of two or more capacitors having the equivalent value of capacitance will not be accepted. The capacitors shall fully comply with IEC 61048 and IEC 61049 or an acceptable equivalent international standard. The terminals of the capacitors shall be screwless terminals with push wire connectors suitable for use with insulated bootlace ferrules.

Plastic container or similar type capacitors will not be accepted. Two or more capacitors connected together to make up the required capacitance with one ballast will not be accepted. The terminals of the capacitors shall be screw less terminals with push wire connectors suitable for use with pin type lugs.

1411.01.3.3 Power Switching Devices

The power switching devices will be operated centrally and automatically by an astronomical time switch installed at the street lighting control cabinet/feeder pillar in order that the lumens output of the lamps can be reduced from 100% to 50% at a pre-set time during the night thus saving energy by approximately 35% to 40%.

The switching devices shall be adequately rated and provide continuously trouble-free service at the arduous weather and temperature conditions specified. The devices shall be manufactured and tested to fully comply with the requirements of the relevant international standards.

1411.01.3.4 Ignitors

The ignitors shall be a separate device, not an integral part of the control gear panel, and shall be fixed inside the control gear compartment of the luminaires.

The ignitors shall be of the electronic solid state and independent superimposed type for operation on a supply voltage of 240 V (+10%/-17.5%), 50 Hz. and shall include an automatic cut-off timer system to prevent repeated re-striking of defective lamps if the lamp does not start within the available time. Ignitors shall have aluminium containers. Pulser type ignitors and ignitors having plastic containers are not acceptable. The ignitors shall fully comply with lEC Publication No. 60926..

Ignitors shall be totally enclosed.

1411.01.3.5 Control Gear Panels

Control gear panels shall be supplied complete with single lamp ballasts and associated power switching devices and capacitors fixed on aluminium sheet panels with all necessary wiring, terminal blocks and hanging hooks.

The overall dimensions of the control gear panels shall be 450mm x 120mm, 550 x 120mm, and 700-750mm x 160mm for single, double, and triple control gear respectively.

The panels shall be made from best quality non-corrosive aluminium sheeting of minimum thickness 3mm for single and double and 4mm for triple control gear assembly. All sides of the panels shall be bent backwards by 10mm, with the edges and corners rounded for ease of handling.

Each panel shall be complete with a 3mm thick galvanized sheet steel hook for hanging the control gear panel inside the column base compartment. The hook shall cover the whole width of the panel, but the projecting part shall be 70mm.The outward projection of the hook shall be 15mm and the lip for hanging, as well as the lip attached to the plate shall be both 25mm wide. The actual location for positioning the hook will be indicated by the MEW/Engineer.

All fixing screws for the different components shall be cross recessed pan-head screws from galvanized steel, and the sizes shall be M6 for the hanging hook, M5 for the ballasts and M4 for all other components. Screws shall be fixed from the front only with galvanized steel hexagonal nuts at the back and be provided with necessary plain and spring washers. The screws used for fixing the ballasts or any other component shall not be used for fixing the hooks.

Terminal blocks shall be suitable for a minimum of 6mm² copper conductors and shall be all single unit type, fixed horizontally on mounting rails, at least 10mm from the bottom of the control gear panels. The number of terminals for single, double, and triple control gear panels shall be 7, 10, and 12, all divided into phase, lamp, neutral and earth terminals as directed and approved by the MEW/Engineer. The neutral and earth terminals shall be linked internally with shrouded jumper strips fixed by screws. Loop-in / loop-out wires for this will not be accepted. All terminals shall be labeled for identification purposes.

An earth terminal consisting of an M6 x 20 hexagon-head brass screw with two nuts and two washers shall be provided at the bottom left-hand corner of all the control gear panels and this shall be suitably wired to the terminal block.

All wiring on the control gear panels shall be carried out with single-core rigid, round, and stranded 2.5mm² copper conductor cables as specified elsewhere in these Specifications.

Each ballast shall be connected separately for power supply and any loop-in / loop-out connection for this will not be accepted. All connections to the terminal blocks, ballasts, capacitors etc. shall be made with the use of proper size of insulated bootlace ferrules and crimping tool. Bare connections without ferrules will not be accepted.

1411.02 400 WATT HIGH PRESSURE SODIUM STREET LIGHTING CUT-OFF LUMINAIRES

1411.02.1 General Requirements

The 400 Watt high pressure sodium cut off luminaires shall meet the requirements as specified for 600 Watt luminaires in Clause 1411.01.1 herein except as follows:

The luminaire shall be designed to operate on 240 Volts, single phase, 50 Hz., supply and to accommodate a 400 watt high pressure sodium lamp, tubular in shape with (E40) cap. The luminaire shall be equipped with an ignitor suitable for the 400 watt high pressure sodium lamp and must be complete with all internal wiring.

The nominal overall dimensions for a 400 watt rated luminaire shall be 750 mm (L) x 350 mm (W). Acceptance of any minor tolerances in the overall dimensions of the luminaire is at the sole discretion of the MEW/Engineer.

The luminaires and lighting columns, shall be configured and arranged as follows:

a 1 No. 400 Watt high pressure sodium luminaire on a 12 m column.

b. 2 Nos. 400 Watt high pressure sodium luminaires displaced at 180^{o} on a 12 m column

c 2 Nos. 400 Watt high pressure sodium luminaires on a common bracket mounted on one side of a 16 m column

d. 4 Nos. 400 Watt high pressure sodium luminaires mounted of a 16 m column, these shall be arranged in two pairs , displaced by 180^{o}

e. 3 Nos. 400 Watt high-pressure sodium luminaires on a common bracket mounted on one side of a 22 m column, in an array of three

f. 6 Nos. 400 Watt high-pressure sodium luminaires mounted on a 22 m column, these shall be arranged in two groups of three , displaced by 180^{o}

1411.02.2 400 Watt HPS Lamps

The 400 W High Pressure Sodium Lamps shall be as specified for the 600W lamps in Clause 1411.01.2 herein, except that lamp characteristic shall be as follows:

a. Power into lamp : 400 watts

b. Total luminous flux (after 100 hours) : 48,000 lumens

c. Average life to burn out to exceed : 16,000 hours

d. At half life, the maintained luminous flux shall be minimum of 75% of the initial luminous flux.

1411.02.3 Control Gear

Control gear for 400 Watt HPS lamps, in general, shall meet the requirements under Clause 1411.01.3 above (control gear for 600 Watt HPS lamps), except that the dual power dimming ballast, power switching device, capacitor, ignitor and all other components shall be suitable for 400 Watt HPS lamps.

14011.03 250 WATTS HIGH PRESSURE SODIUM STREET LIGHTING CUT-OFF LUMINAIRES

1411.03.1 General Requirements

The 250 Watt high pressure sodium cut off luminaires shall meet the requirements as specified for 600Watt luminaires in Clause 1411.01.1 herein except as follows:

The luminaire shall be designed to operate on 240 Volts, single phase, 50 Hz., supply and to accommodate a 250 watt high pressure sodium lamp, tubular in shape with (E40) cap. The luminaire shall be equipped with an ignitor suitable for the 250 watt high pressure sodium lamp and must be complete with all internal wiring.

The nominal overall dimensions for a 250 watts rated luminaire shall be 750 mm (L) x 350 mm (W). Acceptance of any minor tolerances in the overall dimensions of the luminaire is at the sole discretion of the MEW/Engineer.

The luminaires and lighting columns, shall be configured and arranged as follows:

a 1 No. 250 Watt high pressure sodium luminaire on a 10 m column.

b. 2 Nos. 250 Watt high-pressure sodium luminaires mounted on a 10 m column, displaced by 180^{o}..

1411.03.2 250 Watt HPS Lamps

The 250 W High Pressure Sodium Lamps shall be as specified for the 600W lamps in Clause 1411.01.2 herein, except that lamp characteristic shall be as follows:

a. Power into lamp : 250 watts

b. Total luminous flux (after 100 hours) : 27,000 lumens

c. Average life to burn out to exceed : 16,000 hours

d. At half life, the maintained luminous flux shall be minimum of 75% of the initial luminous flux.

1411.03.3 Control Gear

Control gear for 250 Watts HPS lamps, in general, shall meet the requirements under Clause 1411.01.3 above (control gear for 600 Watts HPS lamps), except that the dual power dimming ballast, power switching device, capacitor, ignitor and all other components shall be suitable for 250 Watt HPS lamps.

1411.04 150 WATT HIGH PRESSURE SODIUM STREET LIGHTING SEMI CUT-OFF LUMINAIRES

1411.04.1 General Requirements

The 150 Watt high pressure sodium semi cut-off luminaires shall meet the requirements as specified for 600 Watt luminaires in Clause 1411.01.1 herein except as follows:

The luminaires shall be designed to operate on 240 Volts, single phase, 50 Hz supply and to accommodate a 150 watt high pressure sodium lamp, tubular in shape with (E40) cap. The luminaire shall be equipped with an ignitor suitable for the 150 watt high pressure sodium lamp and must be complete with all internal wiring.

The luminaire shall provide a "semi cut-off" type light distribution, fully in accordance with the relevant IEC,BS, CIE and/or IESNA specifications.

The nominal overall dimensions for a 150 watt rated luminaire shall be 650 mm (L) x 300 mm (W). Acceptance of any minor tolerances in the overall dimensions of the luminaire is at the sole discretion of the MEW/Engineer.

The luminaires and lighting columns, shall be configured and arranged as follows:

a. 1 No. 150 Watt high pressure sodium luminaire on a 6m column.
b. 2 Nos. 150 Watt high pressure sodium luminaires displaced at 180° on a 6 m column.
c. 1 No. 150 Watt high pressure sodium luminaire on a 8 m column.
d. 2 Nos. 150 Watt high-pressure sodium luminaires mounted on a 8 m column, displaced by 180^{o}.

1411.04.2 150 Watt HPS Lamp

The 150 W. High Pressure Sodium Lamps shall be as specified for 600 Watt HPS lamps in Clause 1411.01.2 herein, except that lamp characteristic shall be as follows:

a. Power into lamp: 150 watts
b. Total luminous flux (after 100 hours): 14,500 lumens
c. Average life to burn out to exceed: 16,000 hours
d. At half life, the maintained luminous flux shall be minimum of 75% of the initial luminous flux.

1411.04.3 Control Gear

Control gear for 150 Watt HPS lamps, in general, shall meet the requirements under Clause 1411.01.3 above (control gear for 600 Watt HPS lamps), except that the dual power dimming ballast, power switching device, capacitor, ignitor and all other components shall be suitable for 150 Watt HPS lamp.

1411.05 100 WATT HIGH PRESSURE SODIUM STREET LIGHTING SEMI CUT-OFF LUMINAIRES

1411.05.1 General Requirements

The 100 Watt high pressure sodium semi cut-off luminaires shall meet the requirements as specified for 600 Watt luminaires in Clause 1411.01.1 herein except as follows:

The luminaire shall be designed to operate on 240 Volts, single phase, 50 Hz supply and to accommodate a 100 watt high pressure sodium lamp, tubular in shape with (E40) cap. The luminaire shall be equipped with an ignitor suitable for the 100 watt high pressure sodium lamp and must be complete with all internal wiring.

The luminaire shall provide a “semi cut-off” type light distribution fully in accordance with the relevant IEC,BS, CIE and/or IESNA specifications.

The nominal overall dimensions for a 100 watt rated luminaire shall be 550mm(L) x 250mm(W). Acceptance of any minor tolerances in the overall dimensions of the luminaire is at the sole discretion of the MEW/Engineer.

The luminaires and lighting columns, shall be configured and arranged as follows:

a. 1 No. 100 Watt high pressure sodium luminaire on an 6 m column.
b. 2 Nos. 100 Watt high pressure sodium luminaires displaced at 180° on a 6 m column.

1411.05.2 100 Watt HPS Lamp

The 100 W. High Pressure Sodium Lamps shall be as specified for the 600 Watt lamps in Clause 1411.01.2 herein except that the lamp characteristic shall be as follows:

a. Power into lamp : 100 watts
b. Total luminous flux (after 100 hours) : 9,000 lumens
c. Average life to burn out to exceed : 16,000 hours
d. At half life, the maintained luminous flux shall be minimum of 75% of the initial luminous flux.

1411.05.3 Control Gear.

Control gear for 100 Watt HPS lamps, in general, shall meet the requirements under Clause 1411.01.3 above (control gear for 600Watt HPS lamps), except that the dual power dimming ballast, power switching device, capacitor, ignitor and all other components shall be suitable for 100Watt HPS lamp.

1411.06 CABLING REQUIREMENTS FOR HIGH LIGHTING MASTS AND FOR 6M TO 22 M HEIGHT LIGHTING UNITS

The cabling within the handholes of high lighting masts and column shall allow sufficient slack to enable maintenance at any future time. A minimum of 1.0metre of slack shall be provided in all cases.

1411.07 GUARANTEE

A guarantee certificate shall be submitted as required by Clause 1401.09 of these Specifications to guarantee that the offered luminaires including all parts and components therein will give continuous trouble-free service at Kuwait’s extreme temperature and climatic conditions and that any luminaire and/or any of its parts or components that will fail, breakdown, burn out or mal-function within a period of five (5) years from the date of commissioning of the project will be repaired or replaced and reinstalled free of charge. A guarantee certificate of ten (10) years shall be submitted for the lamp holder cassettes and their locking units.

A guarantee certificate of five (5) years for the dual power dimming ballasts and the power switch, three (3) years for the ignitors and two (2) years for the capacitors shall be submitted.

A guarantee certificate shall also be submitted to guarantee that any lamp that will fail or burn out within a period of two (2) years from the date of commissioning of the project will be replaced and reinstalled free of charge.

1411.08 MEASUREMENT AND PAYMENT

1411.08.1 Method of Measurement and Basis of Payment

Payment for luminaires shall be included with the respective rate for lighting column/mast item in the Bills of Quantities, which includes lamps, control gear, support bracket and all related necessary fittings.

Payment rate shall include inspection and testing of luminaires, as specified in Clause 1416 of these Specifications.

1412 - PERFORMANCE REQUIREMENTS FOR LIGHTING SYSTEMS

1412.01 REQUIREMENTS

Lighting installations shall be designed to accord with the standards set forth in Table 1412.01.

Roadway Designation	L ave(min)	Uo(min)	Ul(min)	TI(max)
Expressway and Freeway	2	0.4	0.7	10
Primary roads/interchange	2	0.4	0.7	10
Secondary roads	1.5	0.4	0.7	10
Local roads/Residential roads	1-0.75	0.4	0.5	15

Table 1412.01 – Roadway Luminance Levels

Where L ave = Maintained Average Road Surface Luminance in cd/m^2 (on whole carriageway)

U_O = Overall luminance Uniformity, L min/L ave

U_l = Longitudinal Luminance Uniformity, L min(in the centre along a driving lane) / L max

TI =Threshold Increment

The above luminance values are based on a hypothetical dry road surface (CIE Classification R3) with the following average values:-Luminance co-efficient (Qo) = 0.07 Specular factor 1 (S1) = 1.11 and Specular factor 2 (S2) = 2.38

Where high mast area lighting techniques are employed lighting performance shall be measured in terms of the horizontal illumination for which an average of 30 lux with a diversity (minimum/average) not greater than 4:1 shall be considered the minimum acceptable standard.

The proposed luminaire shall be such that, under practical conditions the luminance pattern actually obtained from the installation shall be uniform in the longitudinal and lateral axes of the road. Units that produce an excessive ladder or zebra effect, i.e. bright and dark spots, will not be accepted.

The Contractor shall provide detailed computerized calculations to demonstrate that the luminaires proposed meet the criteria for illumination and luminance as given in Table 1412.01.

Upon completion of a lighting installation as specified, the Contractor shall carry out measurement of the illumination levels on the site and submit the results to show that the design levels and uniformities have been achieved.

1413 - LIGHTING SYSTEM FOR UNDERCROSSINGS

1413.01 SCOPE

This Clause pertains to luminaries designed for suspension mounting or surface mounting at under crossings, complete with lamp, fuse and multi-tap built-in ballast.

1413.02 GENERAL REQUIREMENTS

The undercrossing luminaires for interchanges shall consist of 250 watt or 400 watt metal halide or 150 watt high pressure sodium floodlighting luminaires complete with all material as specified herein and as required to provide a complete lighting installation.

An undercrossing luminaire shall consist of housing, cover, reflector, refractor, socket, lamp, fuse, control gear, wiring, latches, screws, washers, pins and other parts composing a complete unit. The luminaire shall provide even illumination, be mechanically strong and easy to maintain. It shall have Class 1 protection with adequate protection against electric shock according to IEC 60598 and a degree of protection minimum IP65 to IEC 60529 against the ingress of dust and moisture under all operating conditions.

The seal between the refractor and the housing shall be adequate to maintain this degree of protection. The refractor shall be held in such a manner as to allow for expansion and contraction of the refractor. The refractor mounting , wiring terminals and control gear components shall be readily accessible . Cable connections to the lampholder within the luminaire shall be of the heat resistant type with silicon, glass fibre or other approved insulation.

The housing and refractor holder shall be made of aluminium or aluminium alloy. The external metal parts shall be finished to resemble polished aluminium. Alloys that darken due to atmospheric exposure, shall be finished by painting grey or other approved colour with a suitable lacquer enamel or other paint as approved by the MEW/Engineer, in accordance with Section 12 (Metal Works) of these Specifications.

The reflector shall be made of aluminium sheet of such grade and quality that:

a. The reflecting surface shall have a specular finish.

b. The reflecting surface shall have a dense protective coating of oxide not less than 1.2 mg/cm^2, applied by the anodic oxidation process.

The reflector shall be of such material and construction as to provide low brightness and minimize glare in the direction of oncoming traffic. The latches, nuts screws, washer, pins and other parts shall be made of non-corrosive metals or of metals with non-corrosive finishes as approved by the MEW/Engineer.

The seal of the optical system shall be accomplished with a gasket material, which will not deteriorate with age. This gasketing shall be continuous and shall assure a weatherproof seal. Suitably located knockouts to suit the conduit used shall be provided in the housing. The lamp socket shall be provided with grips or other suitable means to hold the lamp against vibration.

The terminal of all ballasts, capacitors and control gears shall be shrouded.

1413.03 CONTROL GEAR

The control gear shall form an integral part of the luminaire, in a separate compartment attached to it and be designed to operate the lamp of the power rating and type indicated. It shall be able to start the lamp and control it continuously for ambient temperatures ranging from –15˚C to +55˚C. It shall be suitable for 50Hz, 240V AC + or – 10% and shall regulate the power output to within 12% of rating at this input voltage. It shall operate the lamp without adversely affecting the lamp life and performance as specified herein and have an overall power factor of at least 0.9 when operated under rated lamp load.

The ballast shall have terminals to accept 220V and 240 V supply voltage. Each terminal shall be brought out to a separate shrouded termination. Auto-ballasts may be used only if approval to their use is given by the MEW/Engineer. Multi lamp gear or ballasts operating more than one lamp shall not be employed. The ballast shall be independent single lamp type, encapsulated in an approved resin compound and totally enclosed except where it is an auto-regulator type which may be approved by the MEW/Engineer if it is sealed in a fully weatherproof compartment. The ballast shall be tropicalised and shall generally meet the thermal classifications and other safety and performance requirements as specified in IEC 60923 or an acceptable equivalent international standard. The average life at the site conditions specified shall be guaranteed 10 years minimum.

The capacitor shall be of the diphenyl-impregnated type and shall be in a leak proof aluminium container fitted with a terminator cap and a discharge resistor. Use of soldered connections will not be permitted. The use of a dry film type using metallised polypropylene film will be considered by the MEW/Engineer. The permitted operating temperature of the capacitor shall be marked on its case. The capacitors shall have a value sufficient to raise the power factor to 0.9 or better. Each lamp shall operate using only one ballast and one capacitor. Any combination of two or more capacitors having the equivalent value of capacitance will not be accepted. The capacitors shall comply fully with IEC 61048 and IEC 61049 or an equivalent and approved international standard. The terminals of the capacitors shall be screw-less terminals with push wire connectors suitable for use with insulated bootlace ferrules.

The ignitor for high pressure sodium vapour luminaires shall be of the electronic solid state type and shall be arranged so that the ignitor circuit stops working after the lamp has started . It shall be totally enclosed .The circuit shall include a shunt capacitor to isolate the mains from high frequency start pulses; this capacitor may also be used for power factor correction. The length of wiring between the ignitor and the lamp shall not exceed that recommended by the manufacturer for satisfactory lamp ignition and re-ignition of an extinguished lamp

The Ignitors shall be independent superimposed type for operation on a supply voltage of 240 V (+10%/-17.5%), 50 Hz. and shall include an automatic cut-off timer system to prevent repeated re-striking of defective lamps if the lamp does not start within the available time. It shall have aluminium containers. Pulser type ignitors and ignitors having plastic containers are not acceptable. The ignitors shall fully comply with lEC Publication No. 60926.

1413.04 250 and 400 WATT METAL HALIDE LAMPS FOR UNDERCROSSING

The lamps shall be manufactured and tested to IEC 61167 and shall comply with the following requirements:

a. Power into lamp: 250 watts and 400 watts (metal halide)
b. Total luminous flux: 20, 000 lumens and 32,000 lumens.
c. Average life to burn out is to exceed: 12,000 hours
d. At half life the maintained luminous flux shall be a minimum of 75% of the initial luminous flux.

1413.05 150 WATT HIGH PRESSURE SODIUM LAMPS FOR UNDERCROSSING

The lamps shall be manufactured and tested to IEC 60662 and shall comply with the following requirements:

a. Power into lamp: 150 Watt (high pressure sodium)
b. Total luminous flux: 14,500 lumens after 100 burning hours
c. Average life to burn out to exceed: 16, 000 hours
d. At half-life the maintained luminous flux shall be a minimum of 75% of the initial luminous flux.

1413.06 GUARANTEE

Similar guarantee certificate as asked against Clause 1410.05 of these Specifications shall be submitted

1413.07 MEASUREMENT AND PAYMENT

1413.07.1 Method of Measurement and Basis of Payment

Undercrossing Luminaires shall be enumerated stating the type and size of lamps.

Payment rate shall be at the rate inserted in the Bills of Quantities, which includes luminaire, lamps, control gear, junction box, fittings and fixings.

Junction boxes within abutments shall be enumerated stating the junction box size, number, size and type of circuit breaker(s).

Payment shall be at the rate inserted in the Bills of Quantities which rate shall include junction box and cover (other than those in abutment walls), terminal board, circuit breaker(s), electrical connections and forming recess in concrete(other than the abutment wall).

Payment for junction boxes in abutment walls shall include for circuit breakers and forming recess in abutment walls.

Payment rate shall include inspection and testing of undercrossing luminaire, as specified in Clause 1416 of these Specifications.

1413.07.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1413.1	Undercrossing lighting luminaire (type) (size…W)	nr
1413.2	Junction box (size…) with size and type of circuit breaker(s)	nr

1414 - LIGHTING SYSTEM FOR OVERHEAD GUIDE SIGNS

1414.01 SCOPE

This Clause pertains to luminaires designed for illumination of overhead guide signs mounted on sign support structures, or on bridges, complete with lamp, fuse and multi-tap built-in ballasts.

1414.02 GENERAL REQUIREMENTS

The luminaires shall be metal halide types and shall comprise 2 x 125 watt or 250 Watt lamps , with housing, cover, reflector, refractor, socket, lamp, fuse, ballasts, wiring, latches, screws, pins and other parts composing a complete unit. They shall have Class 1 protection with adequate protection against electric shock according to IEC 60598 and a degree of protection minimum IP65 to IEC 60529 against the ingress of dust and moisture under all operating conditions.

The luminaires shall provide efficient even illumination, be optically sealed, mechanically strong and easy to maintain.

The reflector mounting, wiring terminal, fuse and control gear components shall be readily accessible. The seal between the refractor and the housing shall be adequate to maintain the degree of protection, The refractor shall be held in such a manner as to allow for expansion and contraction of the refractor. Cable connection to the lampholder or within the luminaire shall be of the heat resistant type with silicon rubber, glass fibre or other approved insulation.

The optical system shall consist of a hydroformed aluminium primary beam reflector which shall be precisely profiled and contoured to distribute light across the inner surface of the refractor. The prismatic refractor shall be of moulded borosilicate thermal shock-resistant glass. The inner surface shall have an intricate array of prism to direct light across the face of the sign. The outer surface shall be smooth to facilitate self-cleaning. The reflector shall be of a retro-dispersing type designed to eliminate the halo of excessive luminance to assure more uniform sign luminance.

The terminal board shall be located beneath the reflector at the conduit entry and shall accommodate 10mm² electric cable.

The reflector shall be fastened to the housing by means of a minimum of four stainless steel screws with keyhole slot to facilitate easy removal and replacement. Leveling pads are to be provided on the inside and bottom of the main housing to permit accurate installation.

There shall be mounting brackets within the cast housing to permit the luminaire to be mounted directly to the supporting structure.

The refractor shall be form-fitted to the anodized door frame and shall have a single-piece gasket with a sealing pad to effectively seal the assembly and housing. The assembly shall be fastened to the housing by means of separable hinges at the front and spring tempered stainless steel at the rear. The lamp socket shall be provided with grip or other suitable means to hold the lamp against vibration.

The terminals of all ballasts, capacitor and control gears shall be shrouded.

Each sign lighting system shall be provided with a fusible 30A, 3-Phase, 600 volts rated weatherproof type, safety switch to isolate supply of electrical power to luminaires during maintenance works. Alternatively, a weatherproof safety switch with a miniature circuit breaker (MCB) of 15A, 3-phase 600 volts rated shall be provided.

The sign lighting systems shall be subject to the approval of the MEW/Engineer, who will inspect the equipment in the Contractor's shop before delivery to the job Site. Particular attention shall be given to the mechanical strength of all components, and to the security of their method of attachment to the steel structure of the sign supports.

1414.03 CONTROL GEAR

The control gear shall be designed to operate the lamp and control it continuously for ambient temperatures ranging from –15˚C to +55˚C. It shall be suitable for 50Hz, 240VAC + or – 10% operation and shall regulate the

output power to 12% of this input voltage. It shall operate the lamp without adversely affecting the lamp life and performance as specified herein and have an overall power factor of at least 0.9 when operated under rated lamp load.

The ballasts shall either be of the auto –regulator or tapped type, fully compatible with the lamp operation circuit, shall have terminals to accept 240 V supply, and shall be suitable for satisfactory lamp operation within a supply voltage range of 220 V to 250 V. Each terminal shall be brought out to a separate shrouded termination. Multi-lamp gear or ballasts operating more than one lamp shall not be employed. The ballast shall be independent type single lamp ballast, encapsulated in an approved resin compound and be totally enclosed except where it is an auto-regulator type which the MEW/Engineer may approve if it is sealed in a fully weatherproof compartment. The ballast shall be tropicalized and shall generally meet the thermal classifications and other safety and performance requirements as specified in IEC 60923 or acceptable equivalent international standard. The average life at the site conditions stipulated shall be guarateed 10 years minimum.

The capacitor shall be of the diphenyl-impregnated type and shall be in a leak-proof aluminium container fitted with a termination cap and a discharge resistor. Use of soldered connections will not be permitted. The use of a dry film type using metallized polypropylene film will be considered by the MEW/Engineer. The permitted operating temperature of the capacitor shall be marked on its case. The capacitor shall have a value sufficient to raise the power factor to 0.9 or better. The capacitors shall comply fully with IEC 61048 and IEC 61049 or acceptable equivalent international standards. The terminals of the capacitors shall be screw-less type terminals with push wire connectors suitable for use with insulated bootlace ferrules.

Each lamp shall operate using only one ballast and one capacitor. Any combination of two or more capacitors having the equivalent value of capacitance will not be accepted.

Ballasts and capacitors shall comply with the relevant IEC or equivalent acceptable and approved standards and shall be fully compatible with the complete associated operating lamp circuits.

1414.04 250 WATT METAL HALIDE LAMPS

The lamps shall comply with the following requirements:

a. Power into lamp: 250 watts
b. Total luminous flux: 20,000 lumens
c. Average life to burn out to exceed : 12,000 hours.
d. At half life, the maintained luminous flux shall be a minimum of 75% of the initial luminous flux.

1414.05 TWIN 125 WATT METAL HALIDE LAMPS

The lamps shall comply with the following requirements:

a. Power into lamp: 125 watts each
b. Total luminous flux: 20,000 lumens
c. Average life to burn out to exceed : 12,000 hours.
d. At half life, the maintained luminous flux shall be a minimum of 75% of the initial luminous flux.

1414.06 ILLUMINATION OF SIGN FACES

The illumination of sign faces shall conform to ASSHTO Standards, having the following performance requirements:

a. Maximum luminance of any part of the panel shall not exceed 120 cd/m^2
b. Minimum luminance of any part of the panel shall not fall below 22 cd/m^2
c. Mean luminance (half the sum of the maximum and the minimum values) shall not be less than 65 cd/m^2
d. The ratio between the maximum and minimum luminance shall not be greater than 6:1

1414.07 GUARANTEE

Similar guarantee certificate as asked against Clause 1410.05 of these Specifications shall be submitted

1414.08 MEASUREMENT AND PAYMENT

1414.08.1 Method of Measurement and Basis of Payment

Overhead guide sign illumination shall be enumerated stating the size, type and arrangement of lamps.

Payment shall be at the rates inserted in the Bills of Quantities, which rates shall include the luminaire / lamp, control gear and electrical connections.

Payment rate shall include inspection and testing of overhead sign luminaires, as specified in Clause 1416 of these Specifications.

Safety switches shall be enumerated stating the size and type.

Payment shall be at the rate inserted in the Bills of Quantities which rate shall include enclosure, switch and electrical connections.

1414.08.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1414.1	Overhead guide sign luminaire unit (type) (size) (arrangement of lamps)	nr
1414.2	Safety switch, fusible 30A 3-phase, 600V	nr
1414.3	Safety switch with miniature circuit breaker 3-phase, 15A, 600V	nr

1415 - LIGHTING SYSTEM FOR GROUND MOUNTED GUIDE SIGNS

1415.01 SCOPE

The Contractor shall select and submit for approval a system of sign luminaires and cabling which is compatible, both in appearance and method of installation, with the standard system of sign construction used in this Contract.

Luminaire rating shall include any of the following or combination thereof:

a. 125 watt metal halide reflector lamp (total flux 10,000 lumens)
b. Twin 50 watt metal halide (total flux 2 x 5000 lumens)
c. Twin 600 mm 20 watt white fluorescent (total flux 2 x 1200 lumens)
d. 250 watt metal halide reflector lamp (total flux 20,000 lumens)
e. Twin 125 watt metal halide reflector lamps (total flux 2 x 10,000 lumens)
f. Twin 250 watt metal halide reflector lamps (total flux 2 X 20,000 lumens)

The electrical installation including cabling , conduit , cut-out and plug and socket connection incorporated in the breakaway base flange, shall conform to the quality and safety standards detailed elsewhere in these Specifications and on the Drawings.

The design performance and construction of lighting systems for ground mounted guide signs shall otherwise be generally in accordance with Clause 1414 of these Specifications.

1415.02 MEASUREMENT AND PAYMENT

1415.02.1 Method of Measurement and Basis of Payment

Ground mounted guide sign illumination shall be measured as an item for each ground mounted guide sign.

Payment rate shall include inspection and testing of ground mounted sign luminaires, as specified in Clause 1416 of these Specifications.

Payment shall be at the rate inserted in the Bills of Quantities which rate shall include luminaires, lamps, control gear, cut-out, plug and socket conections to be incorporated in the breakaway base flanges, incoming cable and T-joint connection to power supply, cabling and conduit from the plug and socket connection to the luminaire.

1415.02.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1415.1	Lighting system for ground mounted guide signs (type)	nr

1416 - INSPECTION AND TESTING OF LUMINAIRES FOR UNDERPASSES AND FOR GUIDE SIGNS

The luminaires shall be tested for compliance with the Specifications described herein. However, in lieu of sampling and testing, the MEW/Engineer may accept certified test results from a recognized testing laboratory that the luminaires comply with the Specification prior to shipment to the project Site.

Before starting the installation, every luminaire shall be tested for satisfactory operation. Luminaires that fail to operate properly will be rejected and the Contractor shall furnish new luminaires, which will also be tested for proper operation. The operational test will be carried out at the Contractor's expense.

It shall be the responsibility of the Contractor to ensure that all items supplied on this project comply with the Specifications.

The MEW/Engineer reserves the right to make performance tests, as he deems necessary and to reject those luminaires failing such tests, or those luminaires with inadequate light distribution. The MEW/Engineer shall be the sole judge as to the quality of light distribution, material and workmanship.

1417 – SERVICE CUT-OUTS

1417.01 SERVICE CUT-OUTS FOR LIGHTING MASTS AND COLUMNS

The service cut-out rating for lighting masts and columns shall be as follows:

Lamp	Cut-out
100 Watt High Pressure Sodium	6 Amp.
150 Watt High Pressure Sodium	6 Amp.
250 Watt High Pressure Sodium	10 Amp.
400 Watt High Pressure Sodium	16 Amp.
600 Watt High Pressure Sodium	20 Amp.
1000 Watt High Pressure Sodium	32 Amp.
1000 Watt Metal Halide	32 Amp.

1417.02 SERVICE CUT-OUT, TYPE - R1

This type of cut-out shall be suitable for mounting in the base compartment of the 6m to 10m rigid lighting columns. The cut-out shall comprise of weather-proof and corrosion proof enclosure provided with a single pole miniature circuit breaker (MCB), heat resistant terminal blocks, suitable for looping-in and looping-out 3-core cables, two numbers of compression type cable glands for the above cable connection, cable entry grommets and earth terminal. The overall dimensions of the cut-out shall be:

Height - 260 mms. (Without Cable Glands)
Width-87 mms.
Depth-57 mms.

1417.02.1 Enclosure

The enclosure of the cut-out shall be made from pre hot dipped galvanized sheet steel (zinc coated 275 mg/sq.m – 38.5 microns), must be sufficiently strong and shall not be easily damaged during installation and

maintenance. The thickness of sheet steel of the enclosure and its cover shall not be less than 1.5 mm. A suitably sized cable entry hole with a rubber grommet for the type of cable specified shall be provided at the top. The material of the rubber grommet shall be high temperature resistance and fully suitable for the climatic conditions specified.

The cover of the cut-out shall be fixed to the body with 5 mm. by 15 mm. long pan head stainless steel screws of captive type and one washer shall be provided. Screws made captive by the use of washers or circlips will not be accepted and true captive screws shall be used. Gaskets shall be provided as and where necessary to ensure weather-proofing of the cut-out and is subject to the approval of the MEW/Engineer. The material used for the gasket shall be fully suitable for the temperature variations specified and shall be fixed firmly to remain in its position when the cut-out is opened for maintenance.

The cut-outs shall be painted to a minimum thickness of 80 micron by dry powder epoxy polyester painting.

The cut-out shall be provided with 2 Nos. of 6 mm. by 25 mm. long slotted hexagonal head stainless steel bolts for fixing onto the steel strips inside the base compartment of the lighting column.

A 75 mm. x 30 mm. metal name plate from minimum 1.0 mm. thick non-corrosive material shall be provided with cut-out particulars, manufacturer's name, Contract No. and Year of Manufacture engraved in black by at least 5 mm. height letters.

1417.02.2 Miniature Circuit Breaker

The miniature circuit breaker shall fully comply with IEC60898 and shall have a minimum rated short circuit breaking capacity of 3 KA at 240 Volts. The circuit breakers shall meet the test requirements for the rated short circuit and service short circuit breaking capacities as stipulated in this IEC and the tripping characteristics shall be of the Type "C". All MCB's shall be derated for Kuwait's ambient temperature ($52^{o}C$). The material and the components used in the construction of the MCB shall be fully suitable for the climatic conditions stipulated. The MCB shall be fixed inside the cut-out vertically and the distance of the MCB's operating knob in its center position shall be at 80 mm. from the top of the cut-out.

A.S.T.A or equivalent certificate from an internationally recognized testing station shall be submitted for the type of MCB's offered.

1417.02.3 Terminal Blocks:

Terminal blocks shall be single unit type from polyamide or polycarbonate insulating materials that cannot be easily damaged and are suitable for operation at the severe temperatures specified, free from deformation and cracking. Terminal blocks of porcelain or similar materials shall not be accepted. Also, terminal blocks of exposed metal or protection with removable type of cover will not be accepted. Terminal blocks shall be fixed inside the cut-out firmly and at a suitable place for easy connections.

Terminal blocks shall be mounted vertically with a suitable arrangement for looping-in and looping-out. The distance between the terminal block and the cable glands shall by 75 mm.

1417.02.4 Earthing Teminals

An earth terminal of 6 mm. by 25 mm. hexagonal head brass bolt with two nuts and washers each shall be provided at the top left corner of the cut-out and this shall be wired to the terminal block with green or green-yellow coloured insulated earth wire of the size and type as specified.

1417.02.5 Cable Glands

Cable glands shall be compression type complete with intermediate and connections bushes, locks nuts all made from moulded thermo-plastic or similar material impact and suitable for operation at the severe temperatures as specified, free from deformation and cracking. The glands shall be of adequate size for the size of cable specified.

1417.02.6 Intermediate Wiring inside the Cut-out

All cut-outs shall be supplied complete as specified above and including all intermediate wiring. The wiring between terminal block and the miniature circuit breaker shall be carried out with high temperature Type-TI3 PVC insulated, 600/1000 volts, single core, rigid, round and stranded (type CR, class-2, 7 strands), 2.5 sq.mm. copper conductor cables, all complying with the latest relevant IEC and/or BS specifications. The size of earth wire shall be 6 sq.mm.

All connections to the terminal blocks and the MCB's shall be made with use of proper size of insulated bootlace ferrules and crimping tool. Bare connection without ferrules will not be accepted.

1417.03 SERVICE CUT-OUT, TYPE - R2

This type of cut-out shall be suitable for mounting in the base compartment of the 12 m to 22 m rigid lighting columns. The cut-out shall be same as the Type - R1 cut-out as specified in Clause 1417.02 of these Specifications with the following exceptions.

The overall dimensions of the cut-out shall be:

Height -400 mms. (Without Cable Glands).
Width -160 mms.
Depth-75 mms.

4 Nos. of 5 mm. by 15 mm. long pan head stainless steel screws of captive type shall be provided for fixing the cover.

The cut-out shall consist of a 16 or 20 amp miniature circuit breaker which shall be one, two or three single pole type according to the number of lanterns carried by the lighting column. The numbers of cable entry grommets shall be accordingly fitted at the top.

The rated service short circuit breaking capacity for the 16 & 20 Amp. MCB's as per the IEC:60898 shall be 6 KA at 240/415 volts.

Terminals shall be suitable for 35 sq. mm. conductor. The size of wires between the terminal block and the MCB shall be 2.5 sq.mm. and the earth wire size shall be 10 sq.mm.

The MCB shall be fixed inside the cut-out vertically and the distance of the MCB's operating knob in its center positions shall be at 100 mm. from the top of the cut-out.

The distance between the terminal block and the cable glands shall be 75 mm. when mounted vertically.

1417.04 SERVICE CUT-OUT, TYPE - R3

This type of cut-out shall be suitable for mounting in the base compartment of the lighting high masts. The cut-out shall be same as the Type - R2 cut-out as specified in Clause 1417.03 of these Specifications with the following exceptions.

The overall dimensions of the cut-out shall be:

Height -400 mms. (Without Cable Glands).
Width -300 mms.
Depth-100 mms.

Miniature circuit breakers shall be of 32 Amps. rating and three single pole in numbers.

The cut-out shall be provided a 32 Amp. industrial type switched power socket and protected by a suitably rated miniature circuit breaker .

1417.05 SERVICE CUT-OUT, TYPE - B1

The service cut-out for breakaway lighting columns shall be same as the Type - R1 cut-out as specified in Clause 1417.02 of these Specifications with the following exceptions.

The overall dimensions of the cut-out shall be:

Height -120 mms. (Without Cable Glands).
Width -100 mms.
Depth-75 mms.

Terminals shall be suitable for 6 sq. mm. conductor.

1417.06 GUARANTEE

A guarantee certificate shall be submitted as required by Clause 1401.09 of these Specifications to guarantee that the offered cut-outs including all parts and components therein will give continuous trouble-free service at Kuwait's extreme temperature and climatic conditions and that any cut-out and/or any of its parts or components that will fail, breakdown, burn out or mal-function within a period of two (2) years from the date of commissioning of the project will be repaired or replaced and reinstalled free of charge. A guarantee certificate of five (5) years shall be submitted for the painting of the cut-outs.

1417.07 MEASUREMENT AND PAYMENT

1417.07.1 Method of Measurement and Basis of Payment

All cut-outs shall be supplied complete as specified above and including all intermediate wiring between terminal blocks (looping) and miniature circuit breakers.

All cut-outs shall also be provided with approved type of rubber bushings at the top holes of the cut-outs.

Payment rate shall be included with the respective rate for column or mast item.

1418 - CONTROL CABINETS/FEEDER PILLARS

1418.01 MATERIALS FOR CONTROL CABINETS/FEEDER PILLARS

This Clause pertains to fabricated pre hot galvanized sheet steel control cabinets/feeder pillars for the control of lighting installations. They shall be constructed to be fully suitable for outdoor installation and shall have dimensions as shown on the Drawings.The terminology used in these Specifications for 'control cabinet' implies to one required/employed for Motorway /Expressway lighting systems; whereas the same for 'feeder pilllar' implies to one required/employed for the lighting systems of the local roadways.

Control cabinets/feeder pillars shall be fabricated from sheet steel pre hot dipped galvanized sheet steel 3mm minimum thickness (zinc coated 275mg/sq.m –38.5 microns) and in accordance with the requirements of Section 12 (Metal works) of these Specifications. The construction of the control cabinet/feeder pillar shall be such as to result in a control cabinet/feeder pillar free from distortion after galvanising. To achieve this it may be necessary to provide internal bracing to the control cabinet/feeder pillar walls and doors. The enclosure shall be in one piece without any horizontal joint from outside and a substantial base frame shall be provided at the bottom with all welding from inside only.

The width and depth of the control cabinet/feeder pillar, without canopy, shall be 1050mm x 500mm respectively and the maximum and minimum height between 1700mm and 2000mm.

The roof shall be sloping, extending 50mm on all four sides and with an approximate depth at the center of 100mm. All four sides of the canopy shall be folded inside and welded continuously with the body in a neat manner. Stitch welding shall not be permitted for this.

Each control cabinet/feeder pillar shall consist of two compartments, a top compartment with double insulation and an equipment mounting panel for future installation of street lighting tele-management, smart meters, etc., and a bottom compartment with a separate equipment mounting panel for mounting of phase bus-bars, neutral and earth bars, MCCBs, contactors, outgoing terminals and other components, all wired and ready for use. The overall dimensions of the top component shall be approximately 450mm (H) x 1000mm (W) x 400mm (D) and the compartment shall be designed to carry heavy weights in case dimming/stabilizing transformers for saving energy are to be mounted inside it.

A ventilation system shall be provided incorporating a filter to avoid dust entry into the control cabinet/feeder pillar. Filtered ventilators shall be located at the top and bottom of the two sides and cleaning of the filters shall be possible. The dust filters shall have standard dimensions of 150 mm. (W) x 100 mm. (H) x 4 mm. (Thick).

The compartment doors shall be in two vertical parts, each fitted by a minimum of four 80mm long robust stainless steel hinges. Substantial hanging type hooks shall be provided to hold the doors in open position during working on the control cabinet/feeder pillar. A suitable and substantial latching device, without lock, shall be provided to keep the doors in place when closed. A suitable padlocking arrangement fabricated from 3mm thick steel and galvanized after fabrication with 14mm holes for the padlock shall be provided for locking. The doors shall be gasketed to provide protection against the ingress of moisture and dust to provide a degree of protection IP53 in accordance with IEC 60529. A pocket shall be provided on the inside of the doors for the storage of drawings etc.

The Equipment mounting panel shall be fabricated from 3mm thick pre hot dip galvanized sheet steel and shall be drilled and tapped for front mounting of the pre hot dip equipment. It shall be possible to install and remove the panel easily from the front of the control cabinet/feeder pillar and it shall be provided with an empty space 350mm (H) x 200mm (W) x 150mm (D) at a suitable location for installation of a three-phase kilowatt-hour meter. Adequate clearance and space shall be provided between the busbars for the installation of three ring or busbar CTs for this purpose. All cable connectors shall be to the front of the panel only.

At the front of the equipment mounting panel and inside the control cabinet/feeder pillar, a full length second door from minimum 1.5 mm. thick pre hot dip galvanized sheet steel with necessary slots for the operating knobs of the MCCBs and MCBs shall be provided to prevent any accidental contact with bus-bars or other live material during maintenance. The single leaf door shall be hinged to the body on its left hand side by at least 4 Nos. of substantial stainless steel hinges and shall be closed on the right by captive screws.

Main circuit breakers shall be three pole and the branch circuit breakers shall be single pole Moulded Case Circuit Breakers of the voltage and ampere ratings shown on the Drawings, and shall be fitted with pressure connectors for the wire size shown on the Drawings.

All ratings of main and branch circuit breakers shall be suitably derated for Kuwait climatic conditions; as such, no further derating will be required.

The Moulded Case Circuit Breakers shall comply fully with IEC 60947-2. The rated service short circuit breaking capacity of the main circuit breakers shall be a minimum of 22KA and branch circuit breakers 10KA.

The contactors shall comply with IEC 60947-4-1. The contactors shall have minimum making and breaking capacity in accordance with utilization category AC3 and shall be suitable for minimum Class I intermittent duty. The connection between the contactor and the phase bus-bars shall be by heavy duty high conductivity Copper Bars and the same between the outgoing MCCB and the terminals shall be by 35 sq.mm. XLPE insulated copper cables.

The contactors selected shall be such that all current carrying and live parts shall be properly shielded and it shall not be possible to come into accidental contact with them. All contact assemblies shall be dust protected. The coils of all contactors shall be suitable for operation at a voltage of 240 V +/- 10% in accordance with the Drawings. Contactors may be required to operate circuits which are on full time or during the night only, the particular function being achieved by the appropriate use of manual and automatic switching of their operating coils.

The photoelectric control switch or cell for the control cabinet/feeder pillar shall operate from a supply voltage of 240 volts and be rated for a load of 3000 watts the turn ON shall occur at 40 lux, and turn OFF at 80 lux. It shall operate within a – 5˚C to + 70˚C temperature range. Units shall have fail – safe feature so that the lighting remains energized in the event of component failure. The photo electric control switch shall be housed and

mounted either inside the control cabinet/feeder pillar or at some specified remote position as indicated on the Drawings. When mounted in the control cabinet/feeder pillar a small compartment shall be provided for mounting the photoelectric Control Switch which shall be suitable to allow easy removal of the photo-electric switch in case of cell malfunction. A single pole AUTO-OFF MANUAL selection switch for controlling and bypassing the photoelectric cell, and of the rating shown on the Drawings, shall be provided and properly labelled. A window with suitably sized round holes fitted with 5mm thick clear polycarbonate or plexiglass shall be provided on one side of the control cabinet/feeder pillar to allow operation of the photoelectric cell. The window shall be 150mm long and 100mm wide and shall be fitted with a sliding shutter for closing from the inside.

The control cabinet/feeder pillar shall be supplied and installed with an astronomical time switch in addition to the photo-electric cell. The astronomical time switch shall be from the latest technology, manufactured by a well-reputed renowned manufacturer to relevant international standards and shall withstand Kuwait's extreme weather and temperature conditions. It shall operate on 240 (± 6%) Volts, 50 Hz. power supply, be rated for an electrical load of 2000 watts as a minimum and shall operate within a -5 degree to + 80 degree centigrade temperature range. The astronomical time switch shall be programmed to function as follows:

a. The turn on with full (100%) illumination of the luminaires in the street lighting units shall occur 15 minutes after the sunset.
b. The reduction to fifty per-cent (50%) illumination shall occur at 11:00 PM during the night.
c. The full (100%) illumination shall be re-established one hour before the sunrise.
d. The turn off shall occur 15 minutes before the sunrise.
e. During the darkness at any other time during the daylight hours due to bad weather conditions, provision of overriding the time switch by the photocell shall be available.
f. In the event of malfunction of the astronomical time switch, it shall permit closing of contactor directly to provide full (100%) illumination.

Bus bars shall be of the same ampere rating as the main circuit breaker and shall be made of copper flats or round bars complying with BS 159, and shall be covered with colored PVC sleeving or shall be painted for easy phase identification. Full-length neutral and earth bars shall be provided at the bottom of the equipment mounting panel. An earth or ground bar shall be solidly bolted to the main body of the control cabinet/feeder pillar.

The Neutral and earth bars shall be provided with suitable pressure type terminals for connecting the main neutral and the earth conductors and the number of outgoing terminals shall be sufficient to have minimum 6 nos. of spare terminals. Number of cable glands for 3-core 16 sq. mm. and 5-core 35 sq. mm. cables shall be sufficient for the number of outgoing circuits in addition to 3 nos. spare glands from each type

All wiring within the control cabinet/feeder pillar shall be with XPLE (600/1000 V) insulated copper cables colour coded to the approval of the MEW/Engineer for easy phase identification and shall be arranged neatly and firmly attached. All the wiring leads shall be so arranged to allow current reading with clip-on ammeter in each phase of main incoming and outgoing circuit.

Branch circuits shall be labeled to correspond to the circuit labelling shown on the wiring diagram. A minimum of 3 No. Single phases MCCB's to be provided as spares in each control cabinet/feeder pillar.

The phase terminal blocks shall be all single unit type suitable for 35 sq. mm. copper conductors and the numbers shall be adequate for the outgoing circuits in addition to 6 nos. of spare terminals, all clamped together in an approved manner. The terminals shall be from polycarbonate or polyamide material and terminal blocks of porcelain or similar material will not be accepted.

The terminals for the incoming supply cable shall be fully suitable to receive the size and type of cable to be provided by the Ministry of Electricity and Water. It shall be the Contractor's responsibility to ascertain the size and type of cable to be provided by the Ministry of Electricity and Water.

The control cabinet/feeder pillar compartment shall be insulated on the inside of the sides , back, top and inside of the doors with 25 mm thick fiberglass insulation. The insulation shall be faced on the inside with 1.5 mm thick fibreglass reinforced plastic protective mat.

The control cabinet/feeder pillar shall be provided with two separate gland plates with weather proofing gaskets for securing the cable glands for incoming and outgoing cables. The control cabinets/feeder pillars shall have mounting channels with 18mm diameter holes suitable for M16 anchoring bolts at 600mm x 360mm centres.

A fluorescent bulkhead fitting, complete with a 5 amp miniature circuit breaker, shall be provided inside the control cabinet/feeder pillar , at the top. The fitting shall comprise a pressed aluminium body complete with a hinged white opal polycarbonate cover. The fitting shall have two 300mm, 8 watt, fluorescent tubes with necessary control gear, fixed on a removable reflector tray.

A high quality 13amp power socket for test and maintenance shall be installed internally at an accessible location. It shall be wired and connected to a suitably rated circuit breaker for overload protection. Also, one (1) No. of 16 Amp. Single Pole and one (1) No. of 16 Amp. Triple Pole Miniature Circuit Breakers (MCBs) shall be provided for 24-hour power supply.

Each control cabinet/feeder pillar shall be provided with a 120mm x 50mm non-corroding metal nameplate at the front of the left-hand side door, engraved with details comprising : type, rating, number of outgoing ways etc., the manufacturer's name, and the reference number, for easy identification.

Additionally, two (2) Nos. of 200 mm. x 150 mm. electrical danger signs of approved type, also from non-corrosive metal plates shall be fixed on the control cabinets/feeder pillars, one on the right hand side door and the other at the back side of the control cabinet/feeder pillar.

All fixing screws for the different components shall be from stainless steel of adequate size.

A door lock and 4 No. keys shall be provided for each control cabinet/feeder pillar installed.

The making provision of power supply to the control cabinet/feeder pillar including the incoming supply cables will be by Ministry of Electricity and Water.

1418.02 GUARANTEE

A guarantee certificate shall be submitted as required by Clause 1401.09 of these Specifications to guarantee that the offered control cabinets/feeder pillars including all parts and components therein will give continuous trouble-free service at Kuwait's extreme temperature and climatic conditions and that any control cabinet/feeder pillar and/or any of its parts or components that will fail, breakdown, burn out or mal-function within a period of two (2) years from the date of commissioning of the project will be repaired or replaced and reinstalled free of charge. A guarantee certificate of five (5) years shall be submitted for the painting of the control cabinets/feeder pillars.

1418.03 MEASUREMENT AND PAYMENT

1418.03.1 Method of Measurement and Basis of Payment

The control cabinets /feeder pillars shall each be enumerated, stating the reference as per Drawings.

Payment shall be at the rate inserted in the Bills of Quantities, which rate shall include the complete unit (control cabinet/feeder pillar, control devices, bus-bars, circuit breakers, internal wiring,,etc…) as specified, reinforced concrete foundation,associated manholes, conduits, and protective steel bollard fence and expansion bolts, as detailed on Drawings.

1418.03.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1418.1	Lighting Control Cabinet (type) (rating) (ref. dwg)	nr
1418.2	Lighting Feeder Pillar (type) (rating) (ref. dwg)	nr

1419 - FOUNDATIONS FOR LIGHTING CONTROL CABINETS/FEEDER PILLARS

1419.01 SCOPE

All lighting control cabinets/feeder pillars foundations shall be concrete as shown on the Drawings and shall meet the requirements for quality and construction as specified in Section 5 (Concrete Works) of these Specifications.

The concrete foundations of all street lighting control cabinets/feeder pillars shall be class-K300 and closed type with 100 mm. and 75 mm. diameter uPVC sleeves for incoming and outgoing cables respectively, along with a manhole to facilitate drawing of cables through the uPVC pipes.

The top of the concrete foundation shall be at 50 cm. from the finished ground level and the sides of the foundation shall be grouted and sloped after erecting the control cabinet/feeder pillar on it.

The overall dimensions of the manhole shall be 1000 mm. (L) x 1000 mm. (W) x 1200 mm. (D) with a clear opening of 700 mm x 700 mm. The manhole shall be pre-cast from Class K-300 concrete and frame and cover shall be from Polymer Matrix Composite materials. The frame shall have minimum 4 Nos. of suitably sized robust anchors for anchoring with the concrete. The casting of the manhole shall be performed together with the frame at one time and separate fixing of the frame at site will not be accepted.

The Polymer Matrix Composite frame and cover shall be medium duty type, able to carry a load of minimum 180 KN and must withstand Kuwait's maximum temperature under the open sun, which reaches up to a maximum of 84^{o}C.

The cover of the manhole shall be lockable type, provided with necessary slots with lifting handles and shall be engraved with letters "MEW-SL" of minimum 5cm. height and 5mm deep. The cover shall also be embedded with a suitably sized metal piece at the centre position in order that the manhole can be easily located in case buried under the sand.

The manufacturer shall guarantee the Polymer Matrix Composite frame and cover for a period of minimum ten (10) years against any defect and discoloration.

The manholes shall be installed with their tops aligned with the finished ground level and/or as approved by the MEW/Engineer.

The Contractor shall submit samples of reinforcement steel for the control cabinet/feeder pillar foundation and the manhole along with a sample of complete manhole with Polymer Matrix Composite frame and cover for the MEW/Engineer's approval. No works shall be started at site until and unless the MEW's/Engineer's approval is gained on the samples.

The manholes for the feeder pillars/control cabinets shall not be used as an earth-pit and a separate 500mm (L) x 500 mm (H) x 650 mm (D) earth pit with Polymer Matrix Composite frame and cover shall be provided for all control cabinets/feeder pillars for earthing purposes. A sample of complete earth-pit must be submitted by the Contractor for approval.

uPVC sleeves shall be provided as detailed on the Drawings for entry of power cables.

The foundation shall be cast-in-place and allowed to cure for at least seven days before the control cabinet/feeder pillar is erected.

The control cabinets/feeder pillars which are not within the median barriers shall be provided with a surrounding fence of steel bollards for protection. The bollards shall be placed 1m away from the control cabinet/feeder pillar and shall be fabricated from 75mm diameter hot dip galvanized steel tubes, 1.2m height, having a minimum wall thickness of 3.5mm. The tubes shall have a 3mm thick steel domed cap which shall be continuously welded to the perimeter of the tube, and a 100mm x 100mm x 5mm baseplate shall be welded to the lower end. The tubes shall be filled with class K250 concrete and shall be planted at 600mm centres to a depth of 500mm in a minimum 300 x 300 x 600 deep class K250 concrete foundation cast against undisturbed earth. The bollards shall be painted alternate reflective yellow/black/reflective yellow bands 333mm wide. The paint shall be applied in accordance with the manufacturer's instructions, with particular attention being paid to the preparation and primer required for galvanized surfaces.

The Contractor shall prepare detailed drawings of the posts and layout for the MEW's/Engineer's approval and also submit a sample for approval.

1419.02 MEASUREMENT AND PAYMENT

1419.02.1 Method of Measurement and Basis of Payment

The approved reinforced concrete foundations and manholes for the control cabinets /feeder pillar shall be included within the rate of the control cabinets/feeder pillars item in the Bills of Quantities, including excavation and backfilling, compaction, supply of materials, labor, equipment, tools, supplies and other works items necessary for the proper completion of the work as specified and as detailed on Drawings.

1420 - SAFETY SWITCHES

1420.01 GENERAL

This Clause pertains to safety switches for controlling overhead sign lighting.

1420.02 SAFETY SWITCHES, FUSIBLE, 30 AMPS

The safety switches shall be rated 30 amperes, 600 V AC, 50 Hertz, 3 pole, fusible with insulated neutral terminal and ground lug in an enclosure having a degree of protection IP53 to IEC60529. The switches shall be fused at 15 amperes and shall be fully suitable for external use.

1420.03 SAFETY SWITCHES WITH MINIATURE CIRCUIT BREAKERS

The safety switches incorporate miniature circuit breakers which shall comply with IEC60898 and shall be 3 pole, 15 amperes, 600 V AC with a minimum 4 kA breaking capacity. The switches shall have enclousers having a degree of protection IP53 to IEC 60529. The terminals of the switches shall be suitable for accommodating the incoming supply cables shown on Drawings.

1420.04 JUNCTION BOXES WITHIN THE HANDHOLES OF OVERHEAD GUIDE SIGN SUPPORTS

When an overhead guide sign support permits installation of a junction box inside a handhole, the safety switch specified above shall be non-fused type and the furnishing and installation of the junction box shall be exactly as specified in Clause 1421 of these Specifications for junction boxes within abutment walls for undercrossing luminaires.The rate of the junction box in this instance is to be included in the rate of the safety switch.

1421 - JUNCTION BOXES WITHIN ABUTMENT WALLS FOR UNDERCROSSING LIGHTING

1421.01 JUNCTION BOXES WITH 3 SINGLE-POLE BREAKERS

This work shall consist of furnishing and installing junction boxes of the sizes shown on the Drawings with three single pole miniature circuit breakers at the designated locations for the control of the undercrossing lighting. The three single pole miniature circuit breakers shall be as specified in Clause 1417.04 of these Specifications.

The junction boxes shall be flush mounted at the concrete abutment wall and shall be provided with knockouts which shall agree with the sizes of conduit or pipe shown on the Drawings. Standard locknut spacing must be allowed for proper entry of conduit or pipe to the junction box.

The junction box shall be dust-tight and weatherproof and shall be constructed from sheet steel having a thickness not less that 2 mm.

The junction box and cover shall be hot dip galvanized in accordance with ASTM A 123 and be provided with neoprene gasket material. The cover shall be fastened to the box by means of 4 No. Stainless steel screws of adequate size. Provision shall be made for properly terminating the ground wire inside the box.

The three single pole circuit breakers of the capacity and voltage ratings shown on the Drawings and the terminal board for the neutral wire shall be installed inside the junction box as indicated on the Drawings.

1422 - FINAL ACCEPTANCE INSPECTION

1422.01 GENERAL REQUIREMENTS

When the MEW/Engineer is satisfied that the work is complete, including all testing as specified, the Ministry of Electricity and Water will be informed and will carry out a Final Acceptance Inspection. As part of this Inspection the Contractor shall carry out any tests required by the MEW/Engineer to demonstrate compliance of any item of equipment with the Specification.

The Contractor will be advised of the date of the Final Acceptance Inspection and he shall ensure that all necessary equipment and manpower is available to enable any testing or required inspection work to be carried out..

1422.02 REMEDIAL AND/OR ADDITIONAL WORK

In the event of any aspect of the lighting and electrical works not being in accordance with the specified requirements the Contractor shall, on the written instruction of the MEW/Engineer, carry out any remedial , replacement and/or additional work directed by the MEW/ Engineer to ensure compliance with the specified requirements. The Contractor shall attend and provide for a further Acceptance Inspection of the remedial, replacement and/or additional work. The MEW/Engineer will not accept the lighting and electrical works until all the specified requirements have been complied with.

1422.03 REPORT

The Contractor shall prepare a written report of the Final Acceptance Inspection including the tabulated results of all testing carried out as part of the Final Acceptance Inspection, and incorporating details of all unacceptable work, the remedial , replacement and/or additional works undertaken , the dates of all testing and all other details and information pertaining to the Final Acceptance Inspection.

The report shall be signed by the Contractor and submitted to the MEW/Engineer for his approval and for the final approval of the Ministry of Electricity and Water within one week of the Acceptance Inspection at which all aspects of the lighting and electrical works were accepted.

When approved the Report will be signed by the MEW/Engineer and the Ministry of Electricity and Water's Representative and returned to the Contractor who will provide the original plus four good quality hard copies of the report plus two soft copies on CD to the MEW/Engineer.

The Final Payment Certificate will not be issued until all the Contractor's obligations are fulfilled to the satisfaction of the MEW/Engineer.

1422.04 MEASUREMENT AND PAYMENT

1422.04.1 Method of Measurement and Basis of Payment

Final Acceptance Inspection shall be as an item.

Payment shall be at the rate given in the Bills of Quantities which rate shall include for the costs of the provision of equipment, manpower, carrying out of testing, report writing and reproduction and all other items necessary to carry out the Inspection to the satisfaction of the MEW/Engineer and Ministry of Electricity and Water's Representative.

There shall be no measurement or payment for the remedial replacement and/or additional work, including additional testing and inspection work, which is a consequence of any aspect of the work failing any test or which is due to the Contractor's failure to carry out the works in accordance with the requirements of the Contract Documents.

1422.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1422. 1	Final Acceptance Inspection	LS

SECTION 15: LANDSCAPING AND IRRIGATION WORKS

1500 - GENERAL

The work under this Section shall be performed in accordance with the requirements of the General and Particular Specifications issued by the Public Authority for Agriculture and Fish Resources (PAAFR).

1501 - LANDSCAPING WORKS

1501.01 MEASUREMENT AND PAYMENT

1501.01.1 Basis of Measurement and Payment

Measurement and payment for removal and transplanting of existing palms, trees and shrubs shall be measured and paid by the number of each type as applicable.

Measurement and payment for protection of existing landscape not affected by the works shall be made on completion of the work as a lump sum for the whole of the existing landscape not to be damaged. Any damage to the existing landscape to be preserved caused by the Contractor's operation, shall be repaired by him at his own expense and to the satisfaction of the Engineer/ PAAFR.

1501.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1501.1	Removal and transplanting of existing palms	nr
1501.2	Removal and transplanting of existing trees	nr
1501.3	Removal and transplanting of existing shrubs	nr
1501.4	Protection of existing landscape not affected by the works	ls

1502 - PIPES, VALVES AND FITTINGS FOR IRRIGATION WORKS

1502.01 MEASUREMENT AND PAYMENT

1502.01.1 Basis of Measurement and Payment

Measurement and payment for the supply of pipes, valves, and fittings for Irrigation Works shall be measured and paid in accordance with Clause 803.15 of Section 8 (Materials for Water Works) of these Specifications.

1502.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1502.1	Pipe (Type and Diameter)	m
1502.2	Fittings (Type and Size)	nr
1502.3	Valve (Type and Size)	nr
1502.4	Flow Meter (Type and Size)	nr
1502.5	Surface Box (Size)	nr
1502.6	Valve Chamber Furniture (per Type of Valve)	nr

1503 - EXCAVATION & PREPARATION OF TRENCHES FOR IRRIGATION WORKS

1503.01 MEASUREMENT AND PAYMENT

1503.01.1 Basis of Measurement and Payment

Measurement and payment for Excavation & Preparation of trenches for Irrigation Works shall be measured

and paid in accordance with Clause 901.26 of Section 9 (Water Pipeline Construction) of these Specifications.

1503.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1503.1	Trench Excavation (Pipe Diameter/Depth Stages)	m
1503.2	Trench Excavation across Roadways (Pipe Diameter)	m
1503.3	Excavation of Unsuitable Material (below the required Trench Invert)	cu.m
1503.4	Extra Over for Rock Excavation (in Pipe Trenches)	cu.m

1504 - PIPEWORK, VALVES AND FITTINGS FOR IRRIGATION WORKS

1504.01 MEASUREMENT AND PAYMENT

1504.01.1 Basis of Measurement and Payment

Measurement and payment for laying of pipework, valves and fittings for Irrigation Works shall be measured and paid in accordance with Clause 902.07 of Section 9 (Water Pipeline Construction) of these Specifications.

1504.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1504.1	Pipe (Type and Diameter)	m
1504. 2	Valve (Type and Size)	nr

1505 - VALVE CHAMBERS FOR IRRIGATION WORKS

1505.01 MEASUREMENT AND PAYMENT

1505.01.1 Basis of Measurement and Payment

Measurement and payment for valve chambers for Irrigation Works shall be measured and paid in accordance with Clause 903.06 of Section 9 (Water Pipeline Construction) of these Specifications.

1505.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1505. 1	Valve Chamber (Type and Size)	nr

1506 - ANCHORAGES FOR IRRIGATION WORKS

1506.01 MEASUREMENT AND PAYMENT

1506.01.1 Basis of Measurement and Payment

Measurement and payment for anchorages for Irrigation Works shall be measured and paid in accordance with Clause 904.06 of Section 9 (Water Pipeline Construction) of these Specifications.

1506.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1506.1	Concrete in Thrust Blocks	cu.m

1507 CONNECTIONS TO EXISTING MAINS FOR IRRIGATION WORKS

1507.01 MEASUREMENT AND PAYMENT

1507.01.1 Basis of Measurement and Payment

Measurement and payment for connection to existing mains for Irrigation Works shall be measured and paid in accordance with Clause 908.03 of Section 9 (Water Pipeline Construction) of these Specifications.

1507.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1507.1	Connection to Existing Main (Size and Type)	nr

1508 - REMOVAL AND RECOVERY OR DISPOSAL OF EXISTING MAINS, VALVES AND FITTINGS FOR IRRIGATION WORKS

1508.01 MEASUREMENT AND PAYMENT

1508.01.1 Basis of Measurement and Payment

Measurement and payment for removal and recovery or disposal of existing mains, valves and fittings for Irrigation Works shall be measured and paid in accordance with Clause 909.04 of Section 9 (Water Pipeline Construction) of these Specifications.

1508.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1508.1	Removal and Recovery of Pipes (Diameter and Type)	m
1508.2	Removal and Disposal of Pipes (Diameter and Type)	m
1508.3	Removal and Recovery of Fittings and Mechanical Joints	item

SECTION 16: TRAFFIC SIGNALS

1600 - GENERAL

1600.01 SCOPE

This Section of these Specifications covers the supply, installation, commissioning, guarantee and maintenance of traffic signal equipment as shown on the Drawings and as specified herein.

1600.01.1 Standards and Codes

The Following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

American Association of State Highways and Transportation Officials AASHTO

A policy on Geometric Design of Highways and Streets – 2004

Standard Specifications for Structural Support for Highway Signs, Luminaires and Traffic Signals

AFNOR

NF EN 12368	Traffic Control Equipment-Signal Heads
NF EN 60068-2	Environmental Testing – Part 2
NF EN 60598-1	Luminaires – Part 1: General Requirements and Tests

ASTM

A 27M	Steel Castings, Carbon, for General Application
A 36M	Structural Steel
A 53M	Pipe, Steel, Block and Hot-Dipped, Zinc Coated, Welded and Seamless
A 123M	Zinc (Hot-Galvanized) Coating on Iron and Steel Products
A153M	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A 1008M	Steel, Sheet, Carbon, Cold-Rolled Carbon, Structural, High-Strength Low-Alloy with Improved Formability
A 1011M	Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
C 150	Portland Cement
D 412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers–Tension
D 1737	Method of Test for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus
D 2219	Standard Specification for Poly Vinyl Chloride Insulation for Wire and Cable, 60 °C Operation
D 2220	Standard Specification for Poly Vinyl Chloride Insulation for Wire and Cable, 75 °C Operation
D 2240	Standard Test Method for Rubber Property-Durometer
D 4060	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
E 1036M	Standard Test Methods for Electrical Performance of Nonconcentrator Terrestrial Photovoltaic Modules

BS

BS 2782	Parts 1-6, Methods of Testing Plastics
BS 4607	Part I, Rigid PVC Conduits and Conduit Fittings (Metric)
BS 6004	Electric Cables PVC Insulated, Non-Armored Cables for Voltages up to and Including 450/750 V, Ffor Electric Power, Lighting and Internal Wiring
BS 6346	PVC 46, Rigid PVC Conduits and Conduit Fitting
BS 7430	Code of Practice for Earthing
BS 9000-3	General Requirements for a System for Electronic Components of Assessed Quality Part 3: Specification for the National Implementation of the IECQ System

BS EN 55014	Electromagnetic Compatibility-Requirements for Household Appliances, Electric Tools and Similar Apparatus
BS EN 60228	Conductors in Insulated Cables

CEE

26	Rigid PVC Conduit and Fittings

Institution of Electrical Engineers IEE (UK)

Wiring Regulations for the Electrical Equipment of Buildings

Institution of Electrical and Electronic Engineers IEEE (US)

ANSI-ASQ Z1.4	Sampling Procedures and Tables Packages
ANSI-C 62.41.1	Guide on the Surge Environment in Low-Voltage (1000 V or less) AC Power Circuits
ANSI/TIA/EIA-568B	Commercial Building Telecommunications Cabling Standards
PCCA STD-101	Wireless AT Commands
802.3af-2003	Power Over Ethernet

Institution of Transportation Engineers ITE (US)

VTCSH	Vehicular Traffic Control Signal Heads

International Municipal Signal Association (IMSA)

Specification 19.1 – 19.6
20.1 – 20.6

National Electrical Manufacturers Association (NEMA)

3R	Use Primarily to Provide a Degree of Protection Against Rain, Sleet and Damage from External Ice Formation
250bType 4	Indoor or Outdoor Use Primarily to Provide A Degree of Protection Against Wind Blown Dust and Rain, Splashing Water, Hose-Directed Water and Damage from External Ice Formation
6P	Indoor or Outdoor Use Primarily to Provide a Degree of Protection Against Hose-Directed Water, the Entry of Water During Prolonged Submersion at a Limited Depth, and Damage from External Ice Formation
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)-Identical National Adoption
TS-1-1989	Traffic Control Systems
TS-2-1998	Traffic Control Assemblies with NTCIP Requirements
TC-2-2003	Electrical Polyvinyl Chloride (PVC) Tubing and Conduits

CALTRANS	**State of California Department of Transportation (USA)**
FCC	**Federal Communications Commission (USA)**
HDM	**CALTRANS Highway Design Manual (USA)**
ITS	**Intelligent Transportation Systems (USA)**
KESC	**Kuwait Electricity Safety Code**
K MUTCD	**Kuwait Manual on Uniform Traffic Control Devices**
MC 0141	**UK Department of Transport Specification**
MIL-STD-810	**Environmental Engineering Considerations and Laboratory Testing**
MIL-STD-883	**Test Method Standard Microcircuits**
MUTCD	**Manual on Uniform Traffic Control Devices for Streets and Highways (USA)**

NTCIP	**National Transportation Communications for Intelligent Transportation Systems**
RMDM	**CALTRANS Ramp Metering Design Manual (USA)**
TEES	**CALTRANS Transportation Electrical Equipment Specifications (USA)**
UL 94 VO	**Flame Retardant Epoxies**
Tx DOT	**Texas Department of Transportation – Diamond Configuration**

AWS

D1.1.72 Structural Welding Code

1600.02 DESCRIPTION OF SIGNAL SYSTEM

1600.02.1 Component Sub-systems

At signalised intersections each Automatic Traffic Signal Installation shall consist of the following sub-systems

A. Controller

A microprocessor device which performs the timing & logic functions to control operation of the traffic signals.

B. Signal Heads and Supports

The means by which indications are given to drivers.

C. Vehicle Detectors

Devices for indicating the presence or passage of a vehicle.

D. Pedestrian Detectors

Devices for indicating demand for right of way by a pedestrian.

E. Cabling and Wiring

The means of supplying power to the Controller, and thence to the Signal Heads to cause the display of the appropriate indications; also the means of connecting the Controller to the detectors, push buttons, push button indicators and any other equipment external to the Controllers as detailed on the Drawings.

F. Underground Structures

The ducts and other underground apparatus associated with the cabling. At Emergency Vehicle stations, Alternate Flashing Light signals shall be installed. The sub-systems shall be as listed above except that Vehicle and Pedestrian Detectors shall be replaced by Emergency Detectors which shall be devices for initiating the sequence of Alternate Flashing Light signal operation.

1600.02.2 Definitions

The following definitions apply in this Section of the Specification:

Traffic Actuated Controller	Is a timing device used for the control of traffic signal lights in which the intervals or phases are varied in accordance with demands of traffic as registered by the vehicle actuation of detectors
Cabinet	An Outdoor enclosure for housing the Controller and associated equipment.
Cycle	A complete sequence of signal indications.
Data Transmission System	The system for transmitting messages between the computer centre and the traffic control equipment.

Demand Dependent	A procedure for allowing signal phases to be added to the signal cycle only when a demand for service exists. Demand may be either through Vehicle Detector or Pedestrian Detector or other means external to the signal Controller.
Extension	The additional period (sec) for which a green aspect currently being displaced on a phase shall be extended as a result of one signal actuation of a vehicle detector.
Initial Interval	The first portion of the green signal in a vehicle-actuated phase, to which one vehicle extension is automatically added and to which further vehicle extensions may be added.
Intergreen	The period (sec) between the end of the green signal for one phase and the start of the green period for the next conflicting phase.
Maximum Green	The maximum period (sec) to which a green aspect on a green phase may be extended beyond receipt of a demand for a conflicting phase.
Microprocessor	A device which uses the flexibility of computer electronics on a limited scale. Micro-processors are basically microminiaturized CPU's.
Minimum Green	The minimum period (sec) for which a vehicular green aspect, once displayed on a phase, must be maintained.
MOI	Ministry of Interior (Traffic Department)
Offset	The time difference or interval in seconds between the start of the green indication at one intersection as related to the start of the green interval at another intersection or from a system time base.
Pedestrian Clearance	The minimum period (sec) which must follow the extinguishments of a pedestrian green aspect prior to the display of a conflicting vehicular green aspect on another phase.
Pedestrian Green	The minimum period (sec) for which a pedestrian green aspect, once displayed on a phase, must be maintained.
Phase	The right-of-way and clearance interval in a cycle assigned to movement or any combination of movements.
Red Clearance	The period (sec) which shall elapse from the display of the red vehicular aspect on a phase to the display of a green aspect of the subsequent conflicting phase or phases.
Signal Aspect	A signal display which faces the traffic, consisting of a land receptacle, lamp, lens reflector and housing.
Signal Head	An assembly containing at least three signal aspects, unless it is a signal to pedestrians or an Emergency Vehicle Repeater signal in which case it shall have two aspects.
Solid State Devcies	Solid state devices utilize electronic valves that do not rely on flow of electrons through a vacuum or gaseous space. Components in the solid state class including junction diodes, junction transistors, field effect transistors, MOSFETS, integrated circuits, logic chips, and thermistors.
Split	The portion of the cycle length allocated to each of the various stages in a signal sequence.
Stage	A condition of the signal lights during a period of the cycle which gives right-of-way to one or more particular traffic movements.

Yellow Clearance	The length of time (sec) for which the yellow vehicular aspect following green and proceeding red shall be displayed.

In the particular case of Alternate Flashing Light signal installations the following definitions apply:

Emergency Detector	A device, generally a push button, that shall initiate the sequence of Alternate Flashing Light signal operation or the timing of a pre-set delay period after which the signal operation shall commence.
Emergency Vehicle Repeater Signal	A two aspect signal head situated within an Emergency Vehicle station that shall indicate the period of right-of-way for Emergency Vehicles.
Emergency Vehicle Running Period	The duration for which a red Alternate Flashing Light signal aspect continues to be displayed after one demand has been made by means of an Emergency Detector.
Emergency Vehicle Extension	A fixed additional duration for which a red Alternate Flashing Light signal aspect may continue to be displayed when one additional demand is made during the Emergency Vehicle Running Period.
Both Way Stage	The stage, in dual carriageway operation, where traffic on both carriageways is stopped.
Local Demand	A demand for signal operation which originates at an Emergency Detector at, or adjacent to, the Controller.
Minimum Prevent period	The duration following the extinguishment of a red Alternate Flashing Light signal aspect during which no change of signal can occur.
Remote Demand	A demand for signal operation, which originates at an Emergency Detector remote from the Controller or from some other source.

Right Turn Stage The stage, in dual carriageway operation, where only the traffic stream adjacent to the Emergency vehicle station is stopped.

1600.03 SUB-CONTRACTING REQUIREMENTS

All traffic signal works shall be performed by an experienced Sub-contractor specialising in traffic signal works. Selection of the Sub-contractor shall be subject to the prior approval of the MOI/Engineer.

Any reference in the Traffic Signal Equipment Specifications to responsibilities of the Sub-contractor shall also be construed to mean the Main Contractor who retains the basic overall responsibility for all aspects of the Works.

1601 - GENERAL REQUIREMENTS

1601.01 ENVIRONMENTAL

Climatic conditions in Kuwait are rigorous. During the summer the ambient shade temperature can be in excess of 52°C and during the winter temperatures at night can drop below -6°C. The sun temperature can be in excess of 84°C as measured with a black-bulb thermometer. Periods of high humidity are common and a relative humidity of 100% at 30°C has been recorded. Violent sand and dust storms occur with recorded wind speeds of 110 km/h, gusting to 135 km/h. Even on comparatively still days, fine dust is carried in suspension in the atmosphere. The average rainfall is in the order of 150 mm/annum but this may be concentrated into two or three severe downpours.

All equipment and associated components shall be designed and suitably rated to ensure, with proper maintenance, continuous and trouble-free service under these arduous climatic conditions and shall operate satisfactorily over a temperature range of –35°C to 74°C and under humidity conditions ranging from 10% to 100% at 35°C.

1601.02 ELECTRICAL SUPPLY

All equipment shall be designed, manufactured and installed to operate satisfactorily from at 240 V single-phase 50 Hz source of power. The equipment shall function satisfactorily should the voltage vary within + 15% or – 20% and should the frequency vary within +4%.

1601.03 EQUIPMENT APPROVAL

All equipment shall comprise units of a type that has been used successfully in other installations in a similar environment for a minimum of 6 months and shall be subject to the approval of the MOI/Engineer.

1601.04 COMPLIANCE WITH STANDARDS

All equipment shall comply with the requirements, as appropriate at the date of tender, of the following:

a. Grounding practice shall be in accordance with BS Code of Practice BS 7430
b. Electrical Interference shall not exceed the limits laid down in BS EN 55014 “Limits of Radio Interference”.

1601.05 CORROSION RESISTANCE

All equipment shall be designed to resist corrosion in the Kuwait environment for a period of 20 years.

1601.06 CLEANLINESS

Particular attention shall be given in the design of the equipment to the exclusion of water, moisture, dust, dirt etc., especially where forced ventilation is employed. The Sub-contractor shall avoid the use of components, which may become gummy or may otherwise emit wax and oils.

1601.07 INTERCHANGEABILITY

All equipment shall be so constructed that similar units are readily and completely interchangeable mechanically and electrically.

1601.08 COMPONENTS

All active and passive components, their mounting, and the plugs, sockets and connections shall be suitable for their application. All shall operate well within their ratings with due consideration for the temperature, humidity and environmental conditions within cabinets or enclosures. The Sub-contractor shall be prepared to re-evaluate during the course of the Contract the suitability of any component which has a failure rate higher than that considered typical for such a component. A complete record of component failures shall be maintained during the Guarantee and Maintenance period in order to provide a basis for such an evaluation.

1601.09 COMPONENTS NOT TO BE USED

The following items shall not be used in Automatic Traffic Signal Installations unless authorised in writing by the MOI/Engineer:

a. Thermionic valves
b. Grade I carbon film resistors.
c. High-dissipation resistors of the wirewound type.
d. Germanium transistors

1601.10 PROTECTIVE REQUIREMENTS

The following requirements shall be met:

a. All metal work not normally required to carry current shall be connected to an earth point except where otherwise dictated by transmission or other requirements. Such metal work shall include cases, screens, cable glands, cable conduits, and cable sheaths, etc. NOTICE is given that the Kuwait 240 V power supply is not grounded. Hence, under no condition should the neutral conductor be grounded in any traffic signal equipment.

b. All grounding circuits shall be permanent and electrically continuous with a current carrying capacity high enough and an impedance low enough to limit the potential above ground to a safe level. Grounding shall be accomplished by bonding to copper-clad metal electrodes driven into the earth. Maximum resistance between the ground electrode and any point in the ground system shall not exceed 5 ohms. Connections between ground electrode and the ground wire shall be by a copper screw type positive locking device. No snap-on connections shall be permitted.

c. Connections to underground metallic conduits shall not be deemed sufficient for ground purposes.

d. Insulating bushing shall be provided wherever conductors carrying dangerous voltage pass through holes in metal parts and where the conductors could touch the edge of the holes.

e. Systems shall be completely isolated from the mains supply by means of suitable double-wound transformers, which shall include an earthed screen. The primary and secondary output terminations shall be separated in an approved manner, and the secondary circuits connected, where practicable, to an earthed point.

f. All wiring shall be suitably rated to carry in excess of the current permitted by its fuse, circuit breaker, or other current limiting device. Similar precautions shall be taken to reduce the possibility of overheating components. The maximum voltage drop of any conductor (core) shall not exceed three percent. Provision shall be made in the equipment to prevent damage to circuits due to operation of any fuses or failure of power supplies.

g. All equipment of units working at a voltage of, or above, 150 V DC or 100 V AC (RMS) shall be protected by an approved cover, which shall be removable. The cover shall have a sign with a danger symbol and the voltage. The highest voltage to which access can be had by removal of the cover shall be shown where several different dangerous voltages exist.

h. Terminal strips and terminals shall be clearly and indelibly coded. Terminals carrying mains electrical power shall be segregated from other terminals. Not more than three cable cores shall be retained by any terminal unless approved by the Engineer. All wiring and cabling shall be neat, firm, adequately supported to prevent vibration and so arranged to prevent strain on individual wires.

i. If no other value is specified, the insulation resistance between any two parts not intended to be in electrical contact shall not be less than 100 megaohms, when measured at a voltage appropriate to the equipment. Where “n” such paths are effectively connected in parallel, the resistance of the combination shall be not less than 100/n megaohms.

j. All electrical and electronic equipment shall be protected against electrical surges that may be induced in power mains by lightning, other natural phenomena and man-made electrical disturbances. Multi-use, self-restoring devices shall be provided wherever practicable.

k. Where non-insulated electronic circuits are positioned within 4 mm of a non-insulated tinned surface, a loose barrier of insulated material shall be provided between the surface and the connection to prevent the possibility of unwanted contact. Approved soldered-in lead-through connectors are exempt from this requirement.

1601.11 EXISTING EQUIPMENT

All existing traffic control equipment not necessary for the operation of the proposed signal installation shall be removed by the Sub-contractor. Existing Controllers, associated housings, and other appurtenances shall not be disconnected or removed prior to a direction to this effect being issued by the MOI/Engineer. The Contractor or Sub-contractor shall exercise care in the removal, transport and disposition of all equipment and material. All existing equipment and material removed from the Site shall be delivered to a location as directed by the MOI/Engineer. The Sub-contractor shall not store the removed equipment at the Site.

1601.12 IDENTIFICATION OF EQUIPMENT

The Contractor or Sub-contractor shall mark or label clearly all modules, units, and main parts of the system with a functional code or title, type number, and serial number as approved by the MOI/Engineer. The marking or labelling of main items shall be clearly visible from the outside. The label or marking of encased units or modules shall be visible when the case or cover is removed. Components shall not be marked with circuit references. The markings shall be either adjacent to the component or annotated in the diagram or photograph in the relevant handbook or manual. Markings required for controls, maintenance, or warnings shall be adjacent to the part concerned. Markings shall maintain legibility throughout the life of the equipment in the specified environmental conditions. The techniques to be used shall be subject to the approval of the MOI/Engineer.

1601.13 SIGNAL DISPLAYS

At signalised intersections and pedestrian controlled signalised crossings the signals displayed to drivers shall be arranged red aspect above yellow aspect above green aspect and shall take the following sequence:

Red; Green; Yellow; Red, etc.

Signals displayed to pedestrians shall be arranged as a combination Raised Hand and Walking Person Section with two digit Countdown Timer,and shall take the following sequence:

Raised Hand; Walking Person with Countdown Timer; Raised Hand At Alternate Flashing Light signal installations, the signals on the highway shall be arranged with two red aspects in the same horizontal line with a yellow aspect beneath such that a vertical line through the centre of the yellow aspect bisects a line between the centres of red aspects. The sequence of signal display to drivers on the highway shall be:

Signals Off;

Yellow;

Red aspects flashing alternatively;

Signals Off; etc.

Within the Emergency Vehicle station, one or, where specified, two Emergency Vehicle Repeater Signals(s), arranged yellow aspect above green aspect shall display to emergency drivers the following sequence:

Signals Off; Yellow; Green; Signals Off; etc.

1601.14 EXISTING UTILITIES AND STORM SEWERS

The Contractor/Sub-contractor shall make his own investigation to determine the existence, nature and location of all utility lines and storm sewers and appurtenances thereto within the limit of improvement, and shall be held responsible for all costs in respect of any damage to existing utilities including repairing, rebuilding or replacing it as directed by the MOI/Engineer.

No extra compensation will be allowed to the Contractor or Sub-contractor for any expense incurred because of delay, inconvenience or interruptions to his work or that of his Sub-contractor resulting from compliance with the above requirements.

The Contractor or Sub-contractor shall at his own expense, restore the damaged utility line or appurtenance to a condition equal to that existing before such damage as done, by repairing, rebuilding or replacing it as directed by the MOI/Engineer.

1601.15 EXAMINATION OF SITE

The Contractor or Sub-contractor shall examine the site of the work, to determine all work to be included under the Contract and all conditions to be encountered in performing the work under this Contract.

The Contractor/Sub-contractor, prior to the commencement to the work, shall notify the Ministry of Communication (MOC) and the Ministry of Electricity and Water (MEW), the Ministry of Public Works and Ministry of Interior, Traffic Department of his intent to perform this work. Upon request from the Contractor or Sub-contractor, the Ministry of Communication and the Ministry of Electricity and Water will locate or require the Contractor/Sub-contractor to locate any buried cable, conduit of other electrical and telephone facilities, which may interfere with the Sub-contractor's operations. The Sub-contractor or the Contractor shall report any known or suspected damaged to any electrical or telephone facilities immediately to the MOI/Engineer prior to commencement of work. The MOI/Engineer shall in no way relieve the Contractor or his Sub-contractor of his responsibility for the repair or replacement of facilities damaged by his operations.

In the event of damage occurring to any MEW and MOC or other facilities through the Sub-contractor's operations, the MEW or the MOC or other governmental facilities will require that the System be restored to operation immediately by the Contractor or his Sub-contractor. The repair or replacement shall meet the approval of the MOI/Engineer and the relevant Ministry. The repair shall include all damaged equipment, piping, conduit, etc. All damaged cable shall be replaced in complete spans and all splices shall be in locations permitted in the original installations. No extra compensation shall be allowed to the Contractor or his Sub-contractor for

compliance with these requirements or for any expenses incurred to effect repair to damage electrical, telephone or other facilities.

1602 - CONTROLLERS

1602.01 GENERAL

The following general requirements shall apply:

a. The Contractor or Sub-contractor shall be responsible for the design, supply and installation of new Controllers and associated housings for the traffic signal. The Controllers and housings shall meet or exceed the minimum acceptable requirements contained in the Specifications. All Controllers shall be solid state or microprocessor based in design and meet **CALTRANS 2070** family specifications that comply with and exceed Chapter 9 of CALTRANS Transportation Electrical Equipment Specifications (TEES).

   Contractor or Sub-contractor shall submit the information and documents in the English language and in triplicate, the MOI/Engineer shall reject any offer that does not include the following:

   Full technical details and original Catalogues of the proposed equipments.

   A proof that the Controller is listed in Caltrans Qualified Products List (QPL). A full descriptive original report of the method of Operation of all the traffic Controllers and how it would operate on all types of operations (Computer control, full actuation, semi actuation and fixed time) along with all information of the various controls, parameters and software and range of adjustment for the selected Controller.

   A distributorship agreement between the Sub-contractor and the Controller manufacturer showing the validity dates of the relationship must be submitted. The agreement must be registered with the Ministry of Interior.

   Letter of Guarantee that all equipment including all parts are of first quality.

   Letter of Guarantee of supply of materials components and spare parts for not less than 10 years.

   Must provide a burn-in test certificate for Controller to be supplied.

   The sub-contractor shall give a list of locations (in countries that has the same environmental condition as Kuwait) in which the proposed traffic Controller is installed.

   The Contractor or Sub-contractor shall give a name of location where the proposed traffic Controller operated within a traffic adaptive system.

   The MOI/Engineer reserves the right to reject any proposal if the Documents submitted exclude such information or if they are not acceptable to the MOI/Engineer.

   The Traffic Controller shall be able to operate within a traffic responsive system and especially the QuicNet/4.

b. The Controller unit shall be designed capable of being installed (as a plug-in) in the existing 170 Controller cabinets type 336 without any modifications to cabinet hardware, in addition to the ability to be installed in the ITS cabinets that comply with Chapter 7 of the TEES.

c. The Controller unit shall consist of a Unit Chassis, Front Panel, Motherboard, CPU Module, I/O Module, Communications Module, and a Power Supply that comply with Chapter 9 of the TEES.

d. The Controllers, with housing, shall include all relays, timers, sequence generating devices, logic, associated mounting frames, standby equipment, radio interference suppression devices, shut-down switch and power supply unit, fully wired to terminal blocks and complete and ready to operate the signals at a controlled location.

e. The Contract Drawings indicate the location and layout of each installation. The Contractor or Sub-contractor shall provide the signal stages, sequences and phasing details.

f. The local Controller shall be a digital microcomputer system, designed for traffic signal control. The hardware shall include the microprocessor, memory, operator interface and input/output (I/O) circuits and four serial ports for communication. All logical functions necessarily external to the microprocessor shall be performed by solid-state devices. It shall be completely solid state in design. All instructions, decisions and operations required for traffic signal control by the local Controller shall be provided by software. The timing functions shall be based on digital timing techniques implemented by the microprocessor system. The software shall be fully compatible with existing management system QuicNet/4 in terms of down loading and uploading all programming parameters; time of day, scheduling events, uploading traffic counts and alarm reporting.

g. The Controller memory module shall be as specified by the State of California Department of Transportation for the 2070 Controller in Chapter 9 of the TEES. A minimum of 8 MB of DRAM, organized in 32-bit words, shall be provided. A minimum of 512 KB of SRAM will be available for Operator's use, organized in 16 or 32-bit words shall be provided. The time from the presentation of valid RAM address, select lines, and data lines to the RAM device to the acceptance of data by the RAM device shall not exceed 80 ns and shall be less as required to fulfill zero wait state RAM device write access under all operational conditions.

   The local Controller shall be provided with a minimum of 4 MB of FLASH Memory, organized in 16-or 32-bit words. The main Controller printed circuit board shall be equipped with all necessary circuitry for writing to the FLASH Memory under program control. No more than 1 MB of FLASH Memory shall be used for Boot Image and a minimum of 3 MB shall be available for use. A software settable hardware Time-of-Day (TOD) clock shall be provided. It shall, under on-board standby power maintain an accuracy of ±1 minute per 30 days at 25° C. The clock shall provide a minimum fractional second resolution of 10 ms and shall track seconds, minutes, hours, day of month, month, and year.

h. The local Controller shall execute the minimum requirements for 2070 Controller software. The Controller must comply with the latest TEES and all errata. All versions of the software shall be available to comply with TEES specified cabinets and NEMA TS1 or TS2 Types 1 and 2 cabinets

i. The local Controller with have the dynamic displays listed below to show the operational status of the Controller. Additional displays shall be offered for programming. It shall be possible to jump from a status screen to the appropriate programming screen and return after viewing is complete. When the curser is moved to a dynamic location on the screen, an audible shall be provided when the display changes. When the curser is moved around the status screen and the help key is pressed, a context sensitive help shall be displayed. The Intersection, Controller, Coordination, Preempt and Time of Day status displays shall contain a title line that displays the status being viewed, the Controller status, the current date and time.

   INTERSECTION STATUS display shall indicate a summary of ring, phase, coordination, Pre-emption, transit signal priority (TSP), communications, logic processor flags and time-based control status. It shall be possible to place vehicle, pedestrian, Pre-emption and TSP calls from the keyboard while displaying status information.

   CONTROLLER STATUS display shall indicate current interval, pedestrian, density, maximum, and maximum extension timing by phase and ring. The status of vehicle, pedestrian and overlap signal outputs shall be displayed in combination with vehicle and pedestrian calls. The display shall also show the split plan, timing plan, sequence, action plan and day plan in effect. The display shall include the status of the first sixteen logic processor flags.

   COORDINATOR STATUS display shall indicate the status of vehicle signal outputs in combination with vehicle and pedestrian calls. The display shall also show the split plan, timing plan, sequence, action plan and day plan in effect. Also displayed shall be, current coordination pattern information, local and system cycle count, time-based control status, hold, force-off, vehicle permissive, pedestrian permissive, split count down, split extension, and offset from ring 1.

   PREEMPTOR STATUS display shall indicate the status of vehicle, pedestrian overlap and overlap signal outputs in combination with vehicle and pedestrian calls. Priority (railroad, fire, emergency) preemptors and bus preemptors with calls, preemptor active, inhibit, and delay status. When a preemptor is active, the display shall also indicate preemptor interval, timing, duration, and dwell status. A portion of the display shall indicate the Controller status during Pre-emption including current status, interval, and timing by phase and ring and the status of vehicle and pedestrian signals for each phase.

   TIME BASE STATUS display shall indicate the current time and date, the current day and week program,

the active program step for both coordination pattern and time-of-day functions, the start time of the next eleven program steps and the day the next day plan will start. The programmed selections of the active coordination pattern and time-of-day pattern shall also be displayed.

COMMUNICATION STATUS display shall be communications status displays for Ethernet, Port 1 Synchronous Data Link Control (SDLC), Port 2 (terminal) Port 3, and NTCIP.

An Ethernet status display shall indicate the line speed, the line status, the total number of transmit and receive counts and the number of transmit and receive error counts.

Port 1 (SDLC) status display shall indicate the frame responses from the MMU, the terminal and facilities SIUs and the detector SIUs.

Ports 2 and 3 status display shall indicate the interconnect format, transmit, valid data, data error, carrier detect and the last valid command.

An NTCIP status display shall indicate the total number of SNMP and STMP transmit and receive counts.

DETECTOR STATUS display shall indicate activity for up to 64 detectors. The display shall show detector calls as they are processed by the Controller. The display shall also show the extension and delay timers for the selected detector. In addition the failure status of the detector shall be displayed.

FLASH/MALFUNCTION MANAGEMENT UNIT (MMU) status display shall indicate flash status plus MMU channel, conflict, and monitoring function status. A separate display shall indicate the results of the Controller's comparison of its MMU programming to the programming in the Controller.

INPUT AND OUTPUT STATUS displays shall indicate the activity of all of the logic level inputs and outputs to the Controller.

j. The local Controller shall have programming displays in the form of menus that shall aid the operator in entering data from the front-panel keyboard. A main menu shall allow the user to select a major function of the Controller. A submenu shall then be displayed to allow the user to select a sub-function within the major function. English language and traffic engineering terminology shall be used throughout to facilitate programming. The display organization shall allow traffic personnel to program the Controller without using reference cards or manuals. All data entry and data screens shall be in logical order. Four (4) arrow cursor key shall allow the user to scroll through all programmed data. Programming entries shall consist of alpha-numerical values, YES/NO and ON/OFF entries. During program entry, the new data shall be displayed as it is entered. Two types of consistency checks shall be performed when the ENTER or cursor key is pressed. On constrained data (entries that are constrained by other programmed data), entries shall only be stored when the consistency check is validated. On non-constrained data the entries shall be stored only when the new values are within valid value thresholds. An example of constrained data is the sequence of the phases within a ring. They need to be checked with the phase compatibility, phases in the ring and start phases among others. An example of non-constrained data is the vehicular extension time entry.

   The keyboard entry software shall include context sensitive help screens. Help information shall be accessed by placing the cursor on the data entry in question then pressing the HELP key. Help screens shall be provided for all keyboard entered data and shall include at a minimum range, description, and functional operation information for the data entry.

k. The local Controller shall be configured and timing entries made by the following methods. The manufacturer shall be able to provide as off-the-shelf items all of the firmware and software required to affect the listed methods and to implement network operation with system masters and host PC's.

   Manual data entry via the front panel keyboard.

   Downloading via telemetry from a system master connected to a host PC in a closed-loop system or a central server in an enterprise system.

   Downloading from a portable PC-compatible computer via a serial cable.

   Transfer from one Controller to another, or restoring for a back-up copy, using a data transfer module

(data key).

A minimum of three access levels shall be available to provide programming security.

The highest or administrator level shall have access to all programming entries including setting access codes.

The second or data change level shall have read-write privileges for all programming entries except access codes and CRC enable/disable.

The third or data display level shall only have access to read programmed data and status screen.

User selectable, four-digit access codes shall be provided for the administrator and data change and read only access levels. Each user shall have a user name that is entered using from 6 to 15 characters. Access codes shall initially be set to provide unrestricted access.

If there has been no keyboard activity the Controller shall automatically logoff the user after 30 minutes.

A copy function shall permit copying all timing data from one phase to another. It shall also permit copying all timing plan from one timing plan to another, one detector plan and detector options plan to another, all coordination pattern data from one pattern to another and one sequence to another. This feature will facilitate data entry when programming any two or more phases with the same timing values, or detectors with the same programming, and/or two or more coordination patterns with the same pattern data. Data key, MMU programming jumpers.

The Controller unit shall contain a backup data base with user specified values stored in non-volatile memory. A copy function shall permit transferring the backup database to the active database. The user shall be able to create his own database and copy it to the default database.

A sign-on message shall allow the user to view the Controller software version number. It shall also be possible to display the sign-on message by keyboard selection. The sign-on display shall allow a user-defined message of up to two lines with 38 characters per line.

The Controller shall have the capability to output a memory image of the user programmed settings and intersection configuration data in binary format. This shall allow transferring the memory image data to a data key.

l. The Controller shall be capable of communicating with an on-street system master. This capability shall be provided by a separate telemetry module, which shall be included in the Controller when required by the Drawings and Specifications. The telemetry module shall receive system master commands and data transmissions. In addition, it shall transmit the Controller status, database and system detector information to the system master.

If required by the Drawings and Specifications, a external fiber optic modem or external radio or other means of communications shall be provided instead of the telemetry module. The telemetry module shall allow the Controller to receive, as a minimum, the following commands:

Cycle, offset, and split (coordination pattern)

System sync

Special function commands (minimum of four)

Free and flash mode commands

Time and date

Request for local status

Recall to Max

All commands must occur more than once in any three-second period in order to be recognized.

All mode and special function commands shall be cleared after 20 minutes of loss of communication between Controller and system master.

The status of each of the following functions shall be transmitted to the system master in response to a local status request:

Green and yellow status for all phases and overlaps

Walk and pedestrian clearance status for all phases

Vehicle and pedestrian detector status

Phase termination status

Local time

Coordination status

Command source

Sync or transitioning status of coordinator

Conflict flash status

Local flash status

Preempt activity and calls

Volume and occupancy data from a minimum of 16 system detectors

Speed data from a minimum of two speed detectors

Maintenance required (cabinet door open) status

Status of two user-defined alarms

The status of each of the following parameters shall be calculated on a percycle basis and transmitted to the system master for Split Monitor Reporting:

Actual time spent in each phase

Time of day at end of cycle

Phases forced off during cycle

Type of coordination operation

Whether transitioning to new offset

Cycle, offset, and split in effect during last cycle

Flash status if operation is Free

Upload/Download Capability -The telemetry module shall provide the capability to upload/download the entire intersection database. Phase assignments for overlaps and preemptors shall not be downloaded to preclude unsafe Controller operation. It shall be possible to inhibit downloading of phases in use and left-turn head control. Data transfer shall not require the intersection to be in flash.

Telemetry shall utilize TDM/FSK data transmission from 1200 baud to 9600 baud over two pairs of wires. These may be leased lines (Type 3002, voice grade, unconditioned) or dedicated cable. Optional external fiber optic or wireless communications capability shall also be available.

The nominal transmitter output level shall be 0 dbm into a 600-ohm load. The receiver sensitivity shall be -34 dbm and shall be adjustable from -40 to +6 dbm. Parity and error checking shall be employed to assure

transmission and reception of valid data. Indicators shall be provided on the telemetry module to show telemetry activity as follows: transmit, receive carrier, and valid data.

In the event of a telemetry failure, the Controller shall revert to the noninterconnected coordination mode after it has self-synchronized for a number of cycles, which shall be selectable from 1-254. If the number of cycles is set to 255, the Controller will self-synchronize until a synchronizations pulse is detected.

The Controller shall have the capability of supporting communications with traffic management systems using industry standard protocols with the installation of appropriate optional software. At a minimum the Controller shall have optional software to support the following protocols:

CalTrans Assembly Bill 3418

NTCIP Level 2 as defined by Section 3.3.6 of NEMA TS2-2003. NTCIP v02.06 capabilities shall include all NTCIP mandatory and optional objects. The Controller vendor shall provide access to all Controller data via vendor specific objects. These and all other objects supported by the Controller shall be defined in a standard MIS file.

The Controller shall have the capability of supporting Ethernet communications, using TCP/IP communications protocols. This communications protocol shall utilize the Controller's built-in Network Interface Card and shall not require Ethernet-to-Serial converters.

The Controller shall have the capability of communicating with an external clock like a GPS or WWV clock for setting its internal time of day clock. The Controller shall include a time reset input. This feature shall reset the TOD clock to a preset value whenever the time reset input from the GPS of WWV clock is TRUE.

The Controller shall as a minimum have the following internal communications ports:

Port 1 SDLC for communications to other devices in the cabinet

Port 2 Terminal port for communications with a computer for the purposes of uploading, downloading or upgrading the Controller software

Port 3 Systems communications port. This port shall be provided to either communicate to an on-street master or a central computer system or upgrading the Controller software or database.

A telemetry module shall utilize TDM/FSK data transmission from 1200 baud to 9600 baud over two pairs of wires. Serial communications shall operate at 1200 to 115.2 K baud.

m. The Controller shall include an event log buffer capable of storing a minimum of 200 time and date-stamped events or alarms. Once logged, events shall remain in the buffer until cleared or the log buffer capacity is exceeded at which time the oldest events shall be overwritten.

   At a minimum the following events shall be logged: communication failures, coordination faults, MMU and local flash status, preempt, power ON/OFF, low battery, and status of a minimum of two alarm inputs. An on-line event shall be logged when an event or alarm returns to normal status.

   If security is enabled, an event shall be logged when a user enters a data change. This event shall include the user's ID. It is necessary to log the first change only and not every change. Also an entry shall be recorded when a user logs in and out of the Controller.

   Event logging shall be capable of being enabled or disabled for each category of event or alarm.

n. Additionally, for signalised intersections

   Each Controller shall be capable of implementing timing plans transmitted uniquely to it by the Area Traffic Control central computer, and shall allow for an appropriate interface to a standard outstation transmission unit (OTU) to be located within the same cabinet. Upon data transmission failure, central control failure, or by direct command from central control, the Controller shall continue sequencing using the appropriate self-contained timing plan.

o. Additionally, for pedestrian controlled signalised crossings.

Each Controller shall allow for an appropriate interface to a standard Outstation Transmission Unit (OTU) to be located within the same cabinet. The Controller shall initiate the sequence of signal operation on receipt of a demand from the pedestrian detectors or from the Area Traffic Control Central Computer. The central computer shall not be capable of altering the duration of any period within the sequence of signal operation except vehicle running period.

Upon data transmission failure, central control failure, or by direct commend from central control, the Controller shall operate using the appropriate self-contained timing plan.

1602.02 OPERATIONAL MODES FOR CONTROLLERS AT SIGNALISED INTERSECTIONS

Each Controller shall have the following operational modes:

a. Computer Control
b. Standby (Co-ordinated)
c. Local (Isolated)
d. Manual
e. Flashing
f. Local Pre-emption

Means shall be provided within the Controller housing to select and to test each of these modes of operation. Modes (d), subject to release from computer control, and (e) shall also be selectable via the Police panel facilities. Modes (a) to (c) and (e) shall be selectable from the central control facilities.

1602.02.1 Computer Control Mode

In this mode the cycle length, split and offset implemented shall be that commanded by central computer control.

Subject to any prohibited phase sequences or fixed-duration intervals as specified on the Drawings, the Controller will implement any stage sequence, cycle length, split and offset combination commanded by central control.

Vehicle clearance and other fixed duration intervals shall be timed by Controller circuitry. It shall not be possible to over-ride such timing circuitry or any other safety features of the Controller by control messages from the central computer system or in any other circumstances.

The Controller shall operate in computer control mode when all of the following conditions are satisfied::

a. The selection of this mode is not inhibited at the Controller.
b. The appropriate control message is received from the central computer system.
c. Receipt of no fault indicator from the Controller’s OTU, and
d. The police facilities are not being utilised.

1602.02.2 Standby (Co-ordinated) Mode

The local Controller shall be capable of operating in the standby mode when the central control facilities are unable to maintain communications with the local Controller or when the local Controller does not respond correctly to commands issued from central control.

Both local and central command for standby operation shall be unique for each Controller. The transfer to standby operation of one Controller shall not generally affect the status of other Controllers. It shall be possible; however, to assign Controller into groups whereby the transfer of one of the group to standby control shall automatically transfer the others in that group. This shall be a user selectable function from the central control facility.

Assumption of standby control shall occur rationally and smoothly. No fixed duration intervals shall be altered and no intervals shall be skipped. In the standby mode, the local Controller shall assume operation in a coordinated mode utilizing cable-less linking techniques. The mode of operation shall be assumed under any of the following circumstances:

a. Receipt of appropriate control message from the central computer system;
b. Selection of this mode at the local Controller 's test switch; and

c. Receipt of fault indication from Controller 's OTU during computer control mode operation.

The local Controller shall, as a whole in the standby mode, operate on a predetermined cycle length, offset and cycle split. All of these parameters shall be stored within the Controller and shall be adjustable within the Controller and by downloading of these timings from the central computer system. An actuated Controller in this mode shall operate with the predetermined cycle length as the background cycle. The cycle splits will be based on demands with force off's being issued to limit the splits within the constraints of the predetermined offset and cycle length.

Standby operation shall be accomplished by the local Controller hardware and software. Any one of at least sixteen timing plans (combination of cycle length, offset, or cycle splits) stored in the local Controller shall be available for standby local coordination with other local Controllers in standby local coordinated mode, shall be maintained without the use of direct interconnect cable between Controllers, even following an extended period of mains power failure. The Contractor or Sub-contractor shall describe in detail how synchronization is maintained in his proposed system. The description shall indicate in particular the roles of the central computer system and local Controller in providing this facility. The timing plans shall be available in case of power failure for 1 (one) year minimum.

Upon assumption of standby local coordinated operation, the plan selected for that time of day will be implemented. Timing plan changes shall be implemented rationally maintaining synchronization based on the time clock schedule as long as standby operation continues. Synchronization, and hence relative offset between neighboring Controllers operating in standby local coordinated mode, shall be maintained to an accuracy of one second.

The timing plans shall be selectable through the use of three time-of-day timetables. Each of these three timetables shall allow the timing plans to be implemented on a time-of-day basis with a minimum of 16 changes per day allowed, plan changes may be programmed to occur at intervals of not less than 15 minute a part throughout the day. The timetables to be in effect on any particular day shall be selectable.

The Controller shall be capable of selecting one identified timetable for each of the days, Sundays through Thursdays. One timetable shall be selectable for Saturdays and another for Fridays. These selections shall occur automatically at the local Controller.

As an alternative to the specified method using three timetables, the Sub-contractor may propose alternative facilities for the selection of standby plans on a time-of-day, day-of-week basis. Such an alternative shall provide equal or superior flexibility of operation to the specified method and shall be subject to the approval of the MOI/Engineer.

If the standby timing plans selected by the Controller does not contain valid cycle time, offset and split data, the Controller shall operate in a local isolated mode.

Facilities shall be provided at the local Controller to set and to synchronize the crystal clock used in standby local coordinated operation in the absence of the central computer system. In these circumstances the standby local coordinated mode of operation shall function correctly following a period of mains power failure of up to three days.

1602.02.3 Local (Isolated) Mode

The Controller shall assume operation in this mode when operation in the Standby Mode cannot be maintained, or as required through commands received from central control, or through the local test switch, or where local mode has been selected, in an Actuated Controller as fallback in place of Standby Mode. In this mode of operation, Actuated Controllers shall operate in accordance with local vehicle and/or pedestrian demands, and other Controllers shall operate in accordance with a stage sequence and duration stored in the Controller.

Assumption of standby control shall occur rationally and smoothly. No fixed duration intervals shall be altered and no intervals shall be skipped.

1602.02.4 Manual Mode

In this mode of operation, it shall be possible to step the Controller by hand through a fixed-stage sequence, subject to the restraints of minimum greens and inter-greens but not maximum greens.

Controllers shall be equipped with a means for substituting manual operation of the Controller for the normal automatic operation. The selection of the Manual Mode shall be by means of a switch located in the Police Panel effective when the central control computer has allowed this mode of operation. Means shall be provided to inform the use of the Manual Mode facility whether this mode is currently enabled or inhibited at the local Controller. It shall not be possible to terminate the manual operation of a Controller through a command from central control. In the absence of positive information from the central computer system, the Manual Mode shall be enabled.

When the manual switch is restored the Controller shall revert to Computer Standby or Local Isolated Mode as appropriate, subject to the restraints of any minimum greens or inter-greens.

1602.02.5 Flashing Mode

In this mode, the Controller shall substitute flashing signal indications for the normal specified signal displays. All yellow vehicular aspects shall flash at a rate of between 50 and 75 flashes per minute and shall be illuminated for between 50% and 65% of the time. All other aspects, including pedestrian aspects, shall remain dark.

Means shall be provided to initiate the flashing mode of operation by four methods:

a. A switch located in the Police panel.
b. A switch located in the Controller housing.
c. Through central computer commands. (Applicable only if connected to central computer)
d. By programming on time of day schedule basis.

This mode shall also be introduced automatically in the following circumstances:

a. In the start-up sequence.
b. In the event that the conflict monitor detects a conflict.
c. In the event that the signal lamp monitor detects a circuit failure.
d. On the removal of the signal Controller from its cabinet.

Flashing mode shall only be terminated when all causes for its introduction have been removed.

1602.02.6 Railroad, Fire, and Emergency Vehicle Pre-emption

The Controller shall provide a minimum of ten Pre-emption sequences that can be programmed as either railroad,-fire,-emergency, or bus vehicle Pre-emption sequences. Pre-emption capability shall be standard and shall not require additional modules or software. All pre-emption sequences, timing and operational parameters shall be manually programmable.

The Pre-emptor shall cause normal Controller operation to be preempted when activated by a pre-empt input.

During the operation of this mode, the Controller shall not respond to any instruction from the central computer to select or to enable another mode.

The introduction of the Local pre-emption Mode shall occur immediately on receipt of the input demand, subject only to the maintenance of minimum and fixed duration intervals. On the expiry of the pre-emption period, the operation shall revert smoothly and rationally to the previously applying mode.

The ten railroad, fire, emergency vehicle preemptors shall be selectable as a priority or non-priority type. Priority preemptor calls shall override non-priority preemptor calls. Low-numbered priority preemptors shall override higher-numbered priority preemptor calls. Non-priority preemptor calls shall be serviced in the order received.

Each preemptor shall provide a locking and non-locking memory feature for preemptor calls. If a preemptor is in the non-locking mode and a call is received and dropped during the delay time, the preemptor shall not be serviced.

Preemptor timing intervals shall be programmable from 0-255 in one-second increments or 0-25.5 in one-tenth second increments, depending on function. Delay, max presence, and duration timing intervals shall be programmed from 0-65535 seconds in one-second increments. A programmable delay time interval shall be provided to inhibit the start of the Pre-emption sequence. This interval shall begin timing upon receipt of a Pre-

emption call. This time shall be programmable from 0-65535 seconds in one second increments. An inhibit time shall be provided as the last portion of the delay time interval. During this time, phases that are not part of the preempt sequence shall be inhibited from service. This time shall be programmable from 0-255 seconds in one second increments. A programming option shall be available that allows termination of all phases prior to entering Pre-emption.

A programmable extend input shall cause the preemptor to remain in the dwell interval following the removal of the preempt call. If a preempt call is reapplied during this time, the preemptor shall revert to the start of dwell interval. This time shall be programmable from 0-25.5 seconds in one-tenth second increments.

A programmable duration time shall be provided to control the minimum time that a preemptor remains active. This time shall be programmable from 0-65535 seconds in one second increments.

A programmable maximum presence time shall be provided to control the maximum time that a preemptor input remains active and still be recognized by the Controller. Once failed, the input must return to inactive state to be recognized again. This time shall be programmable from 0-65535 seconds in one second increments.

Phases timing at the beginning of a Pre-emption sequence shall remain in effect for a minimum time before the Controller advances to the next sequential interval. If the phase has been timing for longer than the programmed preemptor minimum time, the Controller shall immediately advance to the next sequential interval. Minimum times shall be programmable for the following intervals:

Green/walk/pedestrian clearance
Yellow
Red

A phase shall advance immediately to pedestrian clearance if it has been timing a WALK interval at the beginning of a Pre-emption sequence. It shall be possible to time the minimum pedestrian clearance through the yellow interval, or alternately to advance immediately to yellow. During Pre-emption, pedestrian indicators shall be selectable as being a solid DONT WALK function, OFF (blank) or fully operational.

If an overlap is in effect when the Pre-emption sequence begins, it shall be possible to terminate the overlap so that it remains red for the remainder of the Pre-emption sequence. Overlaps terminating or forced to terminate shall time the preemptor minimum yellow and red clearance times.

Each preemptor shall provide user-programmable green, yellow and red track clearance intervals. These shall begin timing immediately after the preemptor minimum red interval.

Each preemptor shall provide a user-programmable gate down extension and gate down max green. The gate down extension shall extend the track clearance green time after the gate down input in received. The gate down max green is the maximum the track clearance green time will be extended. If the gate down max green is exceeded the intersection shall be forced to flash.

Up to four permissive phases shall be selectable as track clearance phases. During the track clearance period, the selected phases shall time the track clearance green, yellow and red intervals once, and then advance to the hold interval. If track clearance phases are not selected the track clearance interval shall be omitted from the preempt sequence. Controller interval timing shall be used if track clearance interval times have been programmed as zero.

The Pre-emption hold interval shall begin immediately after track clearance. It shall remain in effect until the preemptor duration time and minimum hold times have elapsed and the preemptor call has been removed or the preemptor maximum time has been exceeded. During the Pre-emption hold interval, any one of the following conditions shall be selectable:

Hold phase green
Limited phase service
All red
Flash

Any valid phase, except a track clearance phase, shall be selectable as a hold phase. If hold phases are not selected, the Controller shall remain in all red during the hold interval. If flash is selected for the hold interval,

up to two permissive phases shall be selectable to flash yellow, and the remaining phases shall flash red. Overlaps associated with the phases flashing yellow shall also flash yellow unless they have been forced to terminate, in which case they shall remain red.

The preemptor shall immediately cause flashing operation if the Pre-emption input and the track interlock input are not in opposite states and the track interlock function is enabled.

Each preemptor shall provide a user-programmable green, yellow and red dwell interval, during which the dwell phase(s) shall operate normally, except that the minimum green interval time shall equal the hold green time. At the completion of the dwell green interval, the Controller shall time the dwell yellow and red clearance intervals prior to transfer to the exit phases.

Up to four permissive exit phases shall be selectable to time after the Pre-emption sequence has been completed. These shall serve as transition phases to return the Controller to normal operation. It shall also be possible to place calls on selected phases upon exiting Pre-emption. The option shall be provided to cause the preemptor to exit Pre-emption to the correct phase to maintain coordination.

Each preemptor shall provide a user-selectable exit timing plan. Upon exiting the Pre-emption sequence, this timing plan shall serve as the phase times in effect for one Controller cycle for all phases.

Preemptor linking shall permit Pre-emption sequences, where lower-priority preemptors may call the higher-priority preemptors from their Pre-emption sequence.

Preemptor active outputs shall be provided for each of the preemptors. The output shall be set to ON when the Pre-emption sequence begins and shall remain ON for the duration of the sequence. It shall also be possible to program preempt active outputs to be ON only during preempt hold intervals. Additionally, it shall be possible to program the non-active, non-priority preemptor outputs to flash while another preemptor is active.

Preemptors shall normally override automatic flash. It shall be possible to inhibit this feature for each preemptor.

1602.02.7 Bus and Transit Vehicle Pre-emption

Ten bus preemptors shall provide control for bus or other low-priority vehicles. Bus preemptors shall have low priority and shall be overridden by railroad, fire, and emergency vehicle preemptor calls.

The preemptor shall be programmed to accept either a 6.25 pulse-per-second signal with a 50% duty cycle or a solid input to identify a bus preemptor call. Bus preemptor calls shall be capable of preemptor call memory and shall be served in the order received.

Bus preemptor timing intervals shall be programmable from 0-255 in one second increments or 0-25.5 in one-tenth second increments depending on the function. A re-service time shall be provided to avoid excessive utilization of the same bus preemptor. If a call is received before the re-service time has elapsed, the bus preemptor shall not be re-serviced. If re-service time has not been entered, then all phases with a call when leaving the bus Pre-emption sequence shall be serviced before the bus preemptor may be served again. Bus preemptors shall provide delay, inhibit, and maximum time functions similar to those for railroad, fire, and emergency vehicle preemptors described above.

Bus preemptors shall provide the following entrance intervals:

Green/walk/pedestrian clearance
Yellow
Red

At the completion of the entrance red clearance, the bus preemptor shall advance to the hold green interval. During this interval, up to four permissive phases shall be selectable to remain green until the minimum hold time has elapsed and the bus preemptor call has been removed or the preemptor maximum time has been exceeded. It shall be possible to program the Controller to allow concurrent phases to be serviced for a bus preemptor with only one phase selected as the hold interval phase.

The Controller shall have pre-emption safeguards so that if a preemptor call is active when power is restored to a Controller, the fault/voltage monitor output shall be set to FALSE, placing the intersection in flash. Similarly, if

external start is applied during a Pre-emption sequence, the intersection shall be set to flash. Intersection flash shall remain in effect until the preemptor call has been removed and the preemptor duration time has elapsed.

An input shall be provided to stop timing of the current active preemptor under control of the MMU/CMU.

A preemptor safety interlock shall be provided to cause the intersection to go into flash whenever the Controller has been replaced and/or has not been programmed for Pre-emption. This shall be achieved with an appropriate signal to the MMU/CMU.

The Controller shall include a transit signal priority (TSP) algorithm that provides for transit vehicle movement through the intersection, while not interrupting coordination or skipping phases.

A check-in detector input shall be provided that senses the arrival of the transit vehicle. When active this input shall initiate TSP.

A TSP delay shall delay the beginning of TSP operation until a set interval after check-in.

A check-out detector input shall determine the departure of the transit vehicle.

Assignment of a single pulse from the check-in detector and check-out detector to the Controller inputs shall be programmable to any Controller input.

When under coordination the TSP sequence shall use adjusted split times to accommodate transit vehicles while maintaining coordination.

When under free operation the TSP sequence shall use adjusted maximum times to accommodate transit vehicle while not skipping phase.

1602.02.8 Pre-emption Status

The Pre-emptor shall provide external outputs suitable for inputs to communications equipment while pre-emption operation is active. The Controller shall provide at least two pre-empt output status bits.

The following Controller displays relating to the Pre-emptor shall, as a minimum, be provided;

- Pre-emption number;
- Current interval; and
- Current phase.

1602.02.9 Pre-emption Activation

The local Controller shall provide the capacity for pre-emption sequences to be activated by use of a pre-emption control panel via direct hard-wire) connection to the Controller. When the pre-emption control panel is activated, it shall cause an input to be placed on the appropriate pre-emption phase or stage of the Controller. The control panel shall be able to call any of the interval pre-emption phases or stages of the Controller.

1602.02.10 Police Facility

A facility to allow Traffic Police to operate the Controller under emergency conditions shall be provided. Traffic Police shall be able to gain access to this Police Panel on the cabinet while not having access to the interior of the Controller cabinet. Any doors that are used to protect the Police Panel from the environment must be equipped with only a simple friction latch closure.

The Police Panel shall incorporate the following features:

a. A control to enable the selection of operational mode. The following shall be selectable:

   i. Manual mode.
   ii. Flashing mode.
   iii. Normal position, this causing the Controller to operate in its appropriate mode.

   The control shall be protected from unauthorised tampering by the use of key switches or other similar devices. Two keys shall be provided for each such device, and where more than one

Controller is being provided the keys for each shall be of an identical pattern. Key switches shall be covered completely by an enclosure to minimise dust problems.

It shall not be possible for the key or other protective device to be removed except when the switch is in the normal position.

b. An indication to inform the use if the Manual Mode is enabled.

c. A control which, when manual mode is operational, will enable the user to call up, at times of his own choosing, the next stage of a fixed stage sequence.

d. A push button to transfer from mains to motor-generator power.

The controls for all other operational features shall be provided elsewhere in the interior of the cabinet.

1602.03 OPERATION OF CONTROLLERS AT PEDESTRIAN CONTROLLED SIGNALISED CROSSINGS

The Controller shall be capable of operation in either Computer Control Mode or Local (Isolated) Mode. On receipt of a demand, either from the Pedestrian Detector or generated by central computer command, the sequence shown in Table 1602.03 shall be commenced subject to the expiry of the Vehicle Running Period. The duration of the Vehicle Running Period shall be determined by the mode of operation of the Controller.

Period	Signals to Vehicles on the Highway	Signals to pedestrians	Duration
B	Red	Red	1, 2 or 3
C	Red	Green (+ Audible Signal)	3 to 7 (in steps of 1 sec)
D	Red	Flashing Green	5 to 18 (in steps of 1 sec)
E	Red	Red	1 to 8 (in steps of 1 sec)
F	Green	Red	Vehicle Running Period

Table 1602.03 Sequence of Signal Operations

On completion of this sequence, the Controller shall return to the quiescent state, with green signals displayed to vehicles and red signals displayed to pedestrians.

1602.03.1 Computer Control Mode

In this mode, a demand for the pedestrian stage may be made at the Pedestrian Detector or generated by central computer control. On receipt of any such demand, the computer shall determine and implement an appropriate Vehicle Running Period, after which the sequence of signal operation shown in Table 1602.03 shall commence. Means shall be provided for the signal operation to be monitored at central computer control but it shall not be possible for the pre-set duration of periods B to E to be overridden.

Any further demand shall have no effect unless received during period E or F, when it shall be stored and implemented at the end of period F.

1602.03.2 Local (Isolated) Mode

In this mode, the duration of the Vehicle Running Period shall be determined by the preset selection of Vehicle Actuated operation, as described in Clause 1602.06.4 of these Specifications or Fixed Vehicle Period operation, as described in Clause 1602.06.6 of these Specifications.

On receipt of a demand from a Pedestrian Detector, but after the expiry of any remaining Vehicle Running Period, the sequence of signal operation shall commence. Timing of the Vehicle Running Period shall commence at the end of Period E. Any further demand shall have no effect unless received during period E, when it shall be stored and initiated at the commencement of period F (the duration of which shall take account of the stored demand), or period F when it shall be initiated in the normal manner.

1602.04 OPERATION OF CONTROLLERS AT ALTERNATE FLASHING LIGHT SIGNALS

Controllers shall cause signals to be illuminated only upon the operation of an Emergency Detector, either at a local or remote location, or by central computer control.

On receipt of such a demand, the Controller shall, unless otherwise specified, initiate the following sequence:

Period	Signals to Vehicles on the Highway	Signals to Emergency Vehicles	Duration (secs)	Extension
A	Yellow	Yellow	5	-
B	Red alternate flashing	Green	15 – 45 (in steps not greater than 5)	5 to 30 (in steps not greater than 5)
C	As B	Signals Off	5	-
D	Signals Off	Signals Off	20	-

Table 1602.04

On completion of the sequence, the Controller shall return to the quiescent state with all signals extinguished.

Except in the case of dual carriageway operation, demands received during period A from the Emergency Detectors shall be inhibited. If a demand is received during period B that period shall be extended as shown above. Any further demand shall have no effect unless it is received in period C or D when it shall be stored but no change of signals shall take place until the end of period D.

The Controller shall be capable of operation in any of the following modes, as specified in the Drawings.

a. Local operation.
b. Local operation with delay period.
c. Local operation at dual carriageways.
d. Local operation at dual carriageways with delay period.
e. Remote operation
f. Remote operation with single delay period.
g. Remote operation with double delay period.
h. Remote operation at dual carriageway.

1602.04.1 Local Operation

The sequence of signal operation shall be immediately initiated by the use of an Emergency Detector situated at the Emergency Detector situated at the Emergency Vehicle Station, located either in a push button box or at another specified position within the station.

1602.04.2 Local Operation with Delay Period

This facility is intended to provide a delay such that the Emergency Vehicle reaches the highway at the commencement of the red flashing signal. On receipt of a demand at the Emergency Detector, a delay period shall commence and on its expiry the signal sequence shall be initiated. This delay shall be in the range 5 to 35 seconds, adjustable in steps not greater than 5 seconds, and shall be set by a manual switch mounted inside the Controller housing. The switch shall not be accessible without unlocking the cabinet door.

An indicator lamp mounted adjacent to the Emergency Detector shall illuminate when the detector is operated, to indicate that the delay period has commenced.

1602.04.3 Local Operation at Dual Carriageways

Where an Emergency Vehicle exits onto a dual carriageway, if it requires to turn right, only traffic signals on the nearside carriageway need be operated. If a left turn is required then signals on both carriageways need be operated. These operations are referred to as the Right Turn stage and Both Ways stage respectively.

Where such signalling is necessary, two Emergency Detectors shall be provided to register local demands. One shall demand the Right Turn stage and the other shall demand the Both Way stage. The two detectors shall be push buttons of the same size but differently coloured and will preferably be mounted on the same push button box but separated by at least 70 mm between centres. Alternatively a separate push button box may be provided but the buttons shall not be separated by more than 300 mm between centres. In either case the buttons shall be clearly and permanently labelled either as RIGHT TURN/LEFT TURN.

Additionally, provision shall be made for two Emergency Vehicle Repeater signals to clearly indicate to drivers of Emergency Vehicles which stage is operating. One repeater only will operate when the Right Turn stage is called and both repeaters will operate when the Both Way stage is demanded.

Normally only one button shall be used for each Controller operating sequence. However, if a demand for the Right Turn stage be followed by a demand for the Both Way stage before the end of period A, the following sequence shall occur; period A for the Right Turn stage, i.e. yellow signal to all vehicles, shall continue and be followed by period B, i.e. green signal to Emergency Vehicle and red flashing signal to vehicles on the nearside carriageway: period A for the Both Way stage shall commence immediately on demand and the yellow signal to vehicles on the offside carriageway shall be displayed: this shall be followed by period B i.e. double green to emergency vehicle and red flashing signals on both carriageways and the sequence shall then be completed in the normal way.

Further operation of the Both Way stage demand button shall have no effect unless the demand is received during period B when the fixed extension to period B shall be initiated, or period C or D, when it shall be stored. Change of stage operation shall not occur if the demand for the Both Way stage is received after the expiry of period A for the Right Turn stage.

A demand for the Right Turn stage received after a demand for the Both Way stage shall have no effect unless received during period C or D, when it shall be stored.

1602.04.4 Local Operation at Dual Carriageways with Delay Period

This mode of operation shall be as specified in Clause 1602.04.3 of these Specifications except that the Controller shall be provided with a delay timer as specified in Clause 1602.04.2 of these Specifications, and that should both the Both Way and Right Turn stages be demanded, the following procedure shall be followed. Should a demand for either stage be received during the delay time after a demand for the opposing stage then that second stage shall also operate at the end of the delay period. If the second demand is received after the expiry of the delay period it shall be stored.

1602.04.5 Remote Operation

Where Controller operation may be required to be initiated from a remote location, the Controller shall be fitted with an isolating input relay and an isolating relay contact output, which shall respond to the remote demand.

The input control channel shall, when operated, cause the Controller to either commence immediately the sequence of operation at period A. The input control relay shall respond to a momentary closure, which exceeds 5 milliseconds duration. Simultaneously the output channel shall commence the confirmation signal and shall not cease until the Controller returns to the quiescent state.

Any local demand by use of the manual push button shall have no effect if the Controller is operating by prior remote demand and has no completed periods A and B except that the receipt of one local demand in period B shall initiate the fixed extension to period B. Any local demand received during period C or D shall be stored and actioned at the end of period D. Operation of the input control relay whilst the Controller is operating shall have no effect unless the demand is received during period C or D.

1602.04.6 Remote Operation with Single Delay Period

When an Emergency Vehicle is called out by remote demand, it may be necessary to provide a delay to allow personnel to reach their vehicle before the signal sequence is commenced. In this case the Controller shall contain the facilities specified in Clauses 1602.04.5 and 1602.04.2 of these Specifications.

If the Controller operation has been initiated by means of a remote demand then any local demand shall have no effect unless received during period B, in which case the fixed extension shall be initiated, or period C or D. In

this case the demand shall be stored and period A shall be commenced at the end of period D, i.e. the delay timer shall not operate.

1602.04.7 Remote Operation with Double Delay Period

In addition to the delay described in Clause 1602.04.6 of these Specifications, it may be necessary to provide a further delay to permit Emergency Vehicles to reach the highway before the red flashing signals commence. In this case the Controller shall contain the facilities described in Clause 1602.04.5 of these Specifications.

Additionally the Controller shall contain a timer that, on receipt of a remote signal, provides a time delay (T2) between the receipt of the demand and a second delay (T1) that commences on the expiry of T2. T1 corresponds with the delay described in Clause 1602.04.2 and shall be followed immediately by the start of period A.

T2 shall be set by a panel mounted switch housed within the Controller and not accessible without unlocking the cabinet door. The delay shall be in the range 5 to 35 seconds in increments not exceeding 5 seconds. The timer T1 may be combined with T2 but two switches shall be provided labelled REMOTE DELAY and LOCAL DELAY, corresponding to T2 and T1 respectively.

If a local demand is received during a remote demand initiated operation, it shall have no effect unless it is received during period B, when the fixed extension to period B shall be initiated, or period C or D when it shall be stored. At the end of period D the sequence shall commence with delay time T1. Similarly a local demand received whilst the Controller is in the quiescent state shall cause the sequence to commence with delay time T1.

If a remote demand is received during a local demand initiated operation, it shall have no effect unless it is received during C or D when it shall be stored. At the end of period D the sequence shall commence with delay time T2.

1602.04.8 Remote Operation at Dual Carriageways

In this mode the Controller shall have the facilities specified in Clauses 1602.04.3 and 1602.04.5 of these Specifications. Where shown in the Drawings single or double timers shall be fitted. The remote signal shall, unless otherwise specified, demand the Both Way stage, initiate the delay timer(s) and cause the output channel to commence the conformation signal.

1602.05 OPERATIONAL FEATURES FOR SIGNALISED INTERSECTIONS

1602.05.1 Local Controller Cycle Length,

One cycle length shall be provided for each coordination pattern. The cycle shall be adjustable over a range of 30-999 seconds in 1-second increments. The cycle length shall serve as the reference time for all coordination timing.

1602.05.2 Local Controller Coordination

Coordination functions to control intersection cycle lengths, system offset relationships, and phase split percentages and shall be provided as a standard Controller feature, with no need for additional modules or software.

A minimum of 120 coordination patterns shall be provided. Each pattern shall allow the selection of an independent cycle length, offset value, and split pattern. The coordination patterns shall be selected using telemetry (system), hardwire, or noninterconnected (time base) coordination commands. Offset and Split values shall be entered in either seconds or percentage. The coordination patterns shall be selected by the coordination command using the following formats:

Pattern -This format shall allow selecting the coordination patterns directly, that is, commanding Plan 1 selects Pattern 1. Pattern command shall include 1-120 patterns, pattern 254 shall select free and pattern 255 shall select flash.

Standard -This format shall allow selecting the coordination patterns using a pattern number derived from a cycle offset-split command. Each pattern shall be assignable to a specific cycle-offset-split combination. The coordination pattern shall be selected programmed by the user to each pattern used.

TS2 -This format shall allow selecting the coordination patterns as a function of Timing Plan and one of three

offsets. With this format a minimum of 20 Timing Plans shall be available for selection of one of sixty coordination patterns.

The following functions shall be programmable in each coordination pattern:

Cycle length
Split pattern
Offset value
Phase sequence
Crosing artery pattern
Permissive timing
Action plan
Coordinated phase split extension
Timing plan
Actuated rest in walk
Phase re-service
Ring extension
Split demand pattern
Ring displacement
Directed split preferences
Special function outputs

1602.05.2.1 Local Controller Synchronization

For systems with a single system sync pulse, coordination timing shall be synchronized to the leading edge of that pulse, which shall serve as the master zero reference for all offset timing.

For hardwire systems with multiple sync pulses, the coordinator shall lock onto the correct sync by trying different syncs and checking for reoccurrence during successive cycles.

After a valid system sync pulse has been received the coordinator shall check for the proper occurrence of the system sync pulse during each subsequent cycle. If a sync pulse does not occur, the coordinator shall self-sync and continue to operate with the last set of coordination commands for a programmable number of cycles from 0-255. If a sync pulse does not occur within the programmed period (or until the first sync pulse is received), the coordinator shall revert to the noninterconnected coordination mode.

1602.05.2.2 Local Controller Free Mode

The coordinator shall provide a free mode of operation, where all coordination control is removed. Free mode operation shall be selectable by coordination commands, by external input or by keyboard entry.

The coordinator shall revert to the free mode when active Controller inputs or functions would interfere with coordination. Such inputs or functions shall include the following:

Manual control enable
Stop time
Automatic flash
Pre-emption

The coordinator shall provide an active free mode, where coordination control is removed but the coordinator continues to monitor system sync so as to keep its timing in step with the system master.

1602.05.2.3 Local Controller Manual Control

The Controller shall allow manual override of the current coordination command from the keyboard. The manual command shall allow selection of any coordination pattern to be in effect.

1602.05.2.4 Local Controller Offset

Offset shall normally be defined as the time period from the system sync pulse to the beginning of the leading coordinated phase green (local zero). The coordinator shall also be capable of referencing the offset to the beginning of the lagging coordinated phase green, coordinated phase yield, or start of yellow point.

Offsets shall be programmable using both percent and seconds. The range shall be from 0-99% of the cycle length in 1% increments or 0-254 seconds in 1-second increments. An offset value of 255 shall result in Free.

Offset changes shall be achieved by adding or subtracting cycle time over a maximum of three cycle periods to allow a smooth transition to the new offset. Other offset change methods shall be adding 20% or a user-selectable value to each cycle or to snap to the sync point once the permissive period are complete and the coordinated phases are green. Offset correction using dwell shall also be selectable.

1602.05.2.5 Local Controller Permissive Periods

Permissive periods shall be provided to control the time period during which coordinated phases are released to service calls on non-coordinated phases.

All permissive timing shall begin at the lead coordinated phase yield point. A yield point shall be automatically computed for the coordinated phase in each ring. The coordinated phase yield points shall allow the coordinated phases to yield independent of each other. The yield point shall be the point at which the coordinated phase is released to allow the Controller to service calls on noncoordinated phases. The computation shall take into account the coordinated phase split interval plus pedestrian and vehicle clearance times.

Automatic permissive period operation shall be provided by automatically calculating a permissive period for each non-coordinated phase. The permissive period shall consist of a separate vehicle and pedestrian period computed from the phase split interval and the vehicle/pedestrian minimum time. The Controller shall answer a call only during the associated phase permissive period. However, once the Controller has been released to answer a call, all remaining phases shall be served in normal sequence. Single permissive period operation shall be provided by defining a single time period per cycle beginning with the yield point during which the Controller is allowed to answer phase calls for any phase. The duration of this period shall be selectable in each coordination pattern.

Dual-permissive period operation shall also be provided. During the first permissive period, the Controller shall answer only vehicle or pedestrian calls on the phases following the coordinated phase. If the Controller yields to a call during this period, calls on the remaining phases are served in normal rotation. During the second permissive period, the Controller shall answer calls on all remaining phases except the first permissive phase. The duration of the two permissive periods, and the time at which to start the second permissive period (displacement), shall be selectable in each coordination pattern.

1602.05.2.6 Local Controller Phase Re-service

If actuated coordinated phases are in use it shall be possible to re-service noncoordinated phases within the same cycle if sufficient time remains. A phase shall be re-serviced only if the permissive period for the phase indicates there is sufficient time remaining in the cycle to service the phase. Phase re-service shall be capable of being enabled/disabled in each coordination pattern.

1602.05.2.7 Local Controller Transition Cycles

It shall be possible to program the Controller to ignore the pedestrian timing when calculating the minimum cycle length for offset correction.

The Controller shall provide a smooth and orderly transition when changing from free operation to coordinated operation and from one coordination command to another.

During a free-to-coordinated transition, the Controller shall initiate a pick-up cycle beginning upon receipt of a sync pulse and a valid coordination command. The Controller shall then enter coordination mode upon crossing a barrier or if resting in the coordinated phases.

Each coordination command shall select a pattern. A command change shall be implemented concurrent with a sync pulse. Cycle, offset, and split changes shall not take effect until local zero.

1602.05.2.8 Local Controller Crossing Artery Control (Dual Coordination)

The coordinator shall be capable of implementing dual coordination at an intersection of two arterials. Once enabled, the coordinator shall place a continuous call on the crossing artery phases so as to ensure that these remain green for their full split interval.

The coordinator shall output a crossing artery sync signal to indicate the beginning of the crossing artery phase split interval.

Dual coordination shall force a selectable crossing artery split plan to be used so as to allow a particular split to be optimized for dual coordination in each coordination pattern.

1602.05.3 Split

Each split shall provide a split interval for each of sixteen phases. The split interval shall be programmable using percent or seconds. The range shall be from 0-99% of the cycle length in 1% increments or 0-255 seconds in 1-second increments.

Split interval settings shall determine the maximum time, including vehicle clearance (yellow and red), for a non-coordinated phase, or the minimum time for a coordinated phase. Phase termination shall be controlled by establishing a force-off point for each phase within the cycle. Except for the coordinated phases, the forceoff point shall be selectable to be a fixed point within the cycle or allowed to float. If floating force-offs are selected, each phase shall time no more than its own split interval.

During coordination, it shall be possible to operate a coordinated phase as actuated or non-actuated. If a coordinated phase is actuated, vehicle detections shall permit the coordinator to extend a phase beyond the normal yield point. Extended coordinated phase green shall be selectable using the same range as split interval settings (percent or seconds). If actuated coordinated phases are used they shall be able to have actuated or non-actuated (walk rest) pedestrian movements.

1602.05.3.1 Local Split Demand

The coordinator shall provide a minimum of two split demand detector inputs, which shall allow the selection of a preferred split plan based on intersection demand.

If the split demand detector indicates continuous vehicle presence during a programmed monitoring period beginning with the onset of a selected phase green, the coordinator shall force a selectable split plan to be in effect during the next cycle. This split plan shall remain in effect for a selected number of cycles from 0-255. A specific split plan shall be capable of being selected in each coordination pattern.

1602.05.3.2 Adaptive Split Demand

The coordinator shall provide a method to select the split using measurement of each phase's green utilization. From this measurement the coordinator shall determine which phase or phases had excess time that was not used during the last measurement period. Then the excess time shall be added to the first set of preferential phases. If the first set of preferential phases gapped out during the last measurement period, then the excess time will be added to a second set of preferential phases. If both sets of preferential phases gapped out during the last measurement period then the time shall be added to the beginning of the coordinated phases.

1602.05.4 Interconnect Modes

The coordinator shall be capable of operating with any of the following interconnect types:

Non-interconnected coordination (time-based)
Telernetry
Hardwired

The coordinator shall be compatible with fixed-time interconnect, which provides the sync pulse superimposed on the offset lines. It shall also operate within an interconnected system using a separate sync line. The non-interconnected coordination mode shall serve as a backup when using telemetry or hardwired interconnect.

1602.05.5 Controller Time Base

Means shall be provided at each local Controller to maintain cable-less synchronization in the event of the loss of the main power for up to twenty-four hours. The correct time of day and day of week shall be made available to the local Controller upon resumption of power in order that appropriate timing plans can be implemented by the standby facilities. A crystal controlled clock or approved alternative device shall be utilized for this purpose. The accuracy of the clock shall be within one minute per month. As described in Clause 1602.01of these Specifications.

1602.05.6 Overlap Circuits

The Controller shall provide sixteen internally-generated overlaps (A -P). All overlap functions shall be programmable from the Controller keyboard.

Overlaps shall be individually programmable as standard, other (to include minus green/yellow, protected, pedestrian protected), with lead and lag overlap timing capabilities. The green, yellow, and red lead and lag interval timings shall be individually programmable with respect to the activation or termination of the parent phase, respectively.

The standard overlap shall require only included phases to be configured.

A protected overlap shall operate according to the following rules:

A protected overlap shall be green, yellow, or red like a normal overlap except its outputs shall be blank when the protected phase is green, or the Controller is transitioning to a non-included phase.

Minus green /yellow overlaps shall operate according to the following rules:

Overlap shall indicate green when any of the overlap phases are green or when in transition between overlapped phases and a modifier phase is not green.

The overlap shall be yellow when an overlapped phase is yellow and the modifier phase is not yellow and none of the overlapped phases are next.

A pedestrian protected overlap shall be green under the following conditions:

When an included phase is green and the protected pedestrian is NOT in walk or pedestrian clearance.

When the Controller is in transition between included phases and a pedestrian protected phase is not next.

After servicing an included phase pedestrian demand if there is enough time before max out to service the overlap minimum green.

The Controller shall provide the capability of sixteen pedestrian overlaps. These shall be capable of overlapping the pedestrian displays of any combination of phases with a pedestrian movement.

1602.05.7 Actuated Facilities

Actuated Controllers are those where, in Local Mode, one or more vehicle or pedestrian phase is called into operation through the use of a detection device. The indication on the Drawings of one or more Vehicle Detector or of a Pedestrian Detector (push button) shall be construed to mean that actuated facilities are required.

Four types of actuated operation are specified:

a. Fully actuated
b. Semi-actuated
c. Partially actuated
d. Demand dependent

A. <u>Fully Actuated Operation</u>

Installations which are designed to operate with two or more phases dependent upon detector actuation for both demand and extension, and where right-of-way rests in the phase last demanded in the absence of any opposing

demand, are considered fully actuated. Each phase shall have associated with it a minimum time period, which is user adjustable individually for each phase. Until this minimum green period has elapsed, the phase shall not be terminated.

A vehicle actuation registered for the phase, which is displaying a green signal shall cause a unit extension to be timed. The phase shall not be terminated during the timing of this interval except by the expiration of the maximum green timer, or by command from central control, or by a change of mode instruction received from the Police panel. Successive vehicle actuations shall cause the timing of the previous unit extension to be cancelled and a new one to begin. The maximum green timer will commence timing immediately upon the registry of demand on an opposing phase. The phase with right-of-way shall retain right-of-way as long as vehicles are spaced such that an additional actuation is received prior to the expiration of the unit extension, which is currently being timed. Right-of-way shall be maintained under these conditions until the maximum green timer expires.

When right-of-way is transferred due to the expiration of a maximum green timer, right-of-way will automatically return to that phase at the earliest available opportunity without detector actuations. A Detector memory circuit, which has been deliberately deactivated will, however, prevent this automatic return of green. Demand for a phase shall in this case be registered only when a Vehicle Detector indicates that a vehicle is within the detection area, and right-of-way shall not be returned to the terminated phase unless vehicle demand is registered.

Right-of-way shall be transferred only through the presence of vehicle demand on the opposing phases or through the operation on recall switches. A preferred sequence for each Controller shall be shown on the Drawings, or otherwise defined by the MOI/Engineer, that establishes an order of service when demand is registered on several phases at a time.

B. Semi-Actuated Operation

Installations which are designed to operate with one or more phase with demand and extend facilities along with a non-actuated phase are considered semi-actuated. Right-of-way will normally rest with the non- actuated phase and transfer away from this phase shall take place as a result of either detector demand or vehicle recall switch activation on the actuated phase. Transfer back to the non-actuated phase will occur at the earliest opportunity in the cycle and will remain for at least its phase minimum time period. Actuated phases shall function in the manner described in (a) above.

C. Partially Actuated Operation

Installations which are designed to operate with two or more non-actuated phases along with one or more demand and extend actuated phase are considered partially actuated. Right-of-way will normally sequence between the non-actuated phases in accordance with the allowed scheme. The actuated phases shall be serviced only when demand has been registered and in accordance with the allowed sequence. Actuated phases shall function in the manner described in (a) and (b) above.

D. Demand Dependent Operation

Installations, which are designed to operate with one or more signal phases called into the sequence through actuation devices are considered demand dependent. Once a demand is received for the phase to be serviced, the Controller will give this phase right-of-way as its next predetermined point in the cycle and will maintain it for the entire pre-programmed period. When no call for a demand-dependent phase is present at the point in the cycle where the phase may be serviced, the phase shall be left out of the sequence for that cycle.

1602.05.8 Time-Based Control Coordination

Pretimed signal Controllers are those where, in Local Mode, all vehicle and pedestrian phases are called into operation in a cyclical manner and for fixed durations. The Controller shall include time-based control. This capability shall be a standard feature and shall not require additional modules or software.

1602.05.8.1 Time Based Clock/Calendar Functions

The Controller shall provide a time-of-day (TOD) clock, which shall be used for all time-based control functions. The only required clock settings shall be the current time (hour, minute and second) and date (month, day and

year). Day of week and week of year shall be automatically computed from the date setting. It shall also be possible to set the number of hours that the local standard time is ahead or behind Greenwich Mean Time.

During normal operation, the TOD clock shall use the power line frequency as its time base. When power is removed, the time shall be maintained by a crystal oscillator for up to 30 days. The oscillator shall have a timing accuracy of +/0.005% over the entire NEMA temperature range as compared to the Universal Coordinated Time Standard. (See Clause 1602.01of these Specifications).

In addition to entering time and date via the keyboard, it shall be possible to download the information from another Controller, a computer or a system master.

The Controller shall include a time reset input. This feature shall reset the TOD clock to 03:30 whenever the time reset input is TRUE.

The TOD clock shall automatically compensate for leap year and shall be programmable to automatically switch to daylight savings time, if applicable.

1602.05.8.2 Time-Based Control

Time-based control shall utilize a day plan program format. The month program shall consist of 200 programmable schedules, each assignable to one of sixteen day programs. Each day program shall consist of from 1 to 50 program steps which define a program for the entire day. Each program step shall be programmed with a starting time and an action plan number. The day plans shall also be assigned to days of the week and days of the month. Time based control shall use action plans to assign:

Coordination pattern number
Vehicle detector plan number
Controller sequence
Timing plan
Vehicle detector diagnostic plan
Pedestrian detector diagnostic plan

Time based control shall also use action plans to enable:

Automatic flash
System override
Detector log
Dimming
Special functions
Auxiliary functions
By-Phase functions
Pedestrian recall
Walk 2 enable
Vehicle extension 2 enable
Vehicle recall
Vehicle max recall
Max 2 enable
Max 3 enable
Conditional service inhibit
Phase omit

There shall be a minimum of 36 holiday or exception day programs, which override the normal day program. Holiday programs shall be capable of being set as floating (occurs on a specific day and week of the month) or fixed (occurs on a specific day of the year). It shall be possible to program a fixed holiday so that it automatically repeats in the following year.

It shall be possible to manually force any of the action plans to override the current action plan. The forced plan shall be entered from the keyboard and shall remain in effect until removed.

1602.05.8.3 Time-Based Coordination

A minimum of 200 time base schedule programs shall be available for the day programs. These shall not have to be entered in any special sequence. It shall be possible to add and delete steps from a day program without affecting any other day program. Each of the program steps shall permit selection of the following functions:

Day program assignment
Start time
Action plan

Selection of system override in an action plan shall allow the coordination pattern selected by the action plan to override the current telemetry or hardwire system commanded coordination pattern.

When operating in the time-based coordination mode the synchronization point for all cycles shall be referenced to a user selected reference time (sync reference), last event or last sync as selected from the keyboard. The sync reference time is that time at which all cycles shall be reset to zero.

If the sync reference time is selected, the synchronization point for the cycle selected by the current program step shall be computed using the present time, sync reference time, and cycle length. The synchronization point shall occur whenever the present time is such that an even number of cycle length periods has occurred since the sync reference time.

1602.05.9 Pedestrian Features

The Controller shall have the capability of providing standard pedestrian signal displays through adjustable timed intervals and output devices. The means to accomplish this shall be similar to the means provided for the vehicular phases and shall be contained within the same control unit.

Pedestrian phases may be either concurrent or exclusive as may be indicated on the Drawings. The Controller shall be capable of providing the standard steady “prohibited” indication, a steady “right-of-way” indication, and a flashing “clearance” indication. In addition, it may be required to provide a flashing “right-of-way” indication rather than the steady indication. Concurrent pedestrian phases shall be capable of starting later, or finishing earlier, than the associated vehicular phase by means of an adjustable fixed interval.

Each Controller must be capable of controlling pedestrian signal groups in a direct relationship with the number of stages that can be handled by that Controller. Controllers with four-stage capabilities must be capable of controlling four pedestrian groups and Controllers with eight-stage capabilities must be capable of controlling eight groups.

Actuated and Demand-Dependent Controllers shall have the capability of having pedestrian phases actuated through the use of a Pedestrian Detector.

At intersections where pedestrian features are provided, an additional signal aspect may be required as shown on the Drawings. This additional display is in the form of flashing yellow indication that operates when an associated green and pedestrian indication are being displayed. The flashing rate and duration shall be as specified in Clause 1602.02.5 of these Specifications.

A means shall be provided, for each demand-dependent pedestrian phase, to enable lamps at each push button for that phase to be illuminated when a demand is received. These lamps shall remain illuminated until a green pedestrian aspect is displayed on that phase, whereupon they shall be extinguished.

Where the Drawings show one or more pedestrian push button, then this facility shall be made operational for all such phases.

1602.05.10 Downloading Controllers Parameters

It shall be possible to download all sequences and operational parameters of the Controller and all other internal software modules of the Controller. This shall be accomplished through the use of a microcomputer, microprocessor or through the management system QuicNet/4 existing at the traffic department. If downloading

is done by means other than microcomputer, all components and equipment and software required for the downloading process, including connectors, cables, and modules etc. shall be furnished with the Controller.

The site configuration shall provide a detailed description of the downloading operation

1602.05.11 Diagnostics

The Controller shall include both automatic and operator-initiated diagnostics. This capability shall be a standard feature and shall not require additional modules or software.

Automatic diagnostics shall verify memory and microprocessor operation each time power is reapplied to the Controller. After power has been applied, diagnostics shall continually verify the operation of essential elements of the Controller including at a minimum: memory, communications, and the microprocessor.

Facilities shall be provided so that appropriate diagnostic information is collected and stored by the microprocessor regarding faults in its peripheral equipment.

1602.05.12 Programmme and Data Integrity

Appropriate facilities shall be provided to ensure the functional integrity of the program and fixed data. All memory components used to store program and fixed data for the Controller shall be tested individually by check-sum validation techniques. Each memory component shall have its own unique check-sum value set according to the data stored in the component.

Each of the memory components shall be individually check-summed during the start-up procedure. During normal operation of the Controller, an individual check-sum of each of the memory components shall be made at intervals not exceeding ten seconds.

Read-write memory space, including storage of timing data that may be changed by an operator and workspace used by the microprocessor during processing, shall undergo check-sum testing in the same manner as other memory components.

If a check-sum error is detected, an indication on the front panel of the Controller identifying the check-sum error shall be illuminated and the Controller shall immediately be placed in flashing operation. If a check-sum error occurs, the Controller must manually reset before normal operations can resume.

1602.05.13 Watchdog Timer

The Controller shall be provided with a watchdog timer which will check that the microprocessor is executing its programs, if the microprocessor does not reset the watchdog timer at the appropriate times, the watchdog timer will expire. Upon expiration, the watchdog timer will cause the local Controller to be placed in flashing operation. If the watchdog timer places the local Controller in flashing operation, the local Controller will have to be manually reset before normal operations can resume.

1602.05.14 Signal Lamp Monitoring

A Bulb monitor must be provided based on current detection of the signal circuits. It shall allow maintenance personnel to determine where the failure has occurred to the extent possible with the monitoring technique used. The bulb monitor shall upon a lamp failure transmit an alarm to the control center indicating the circuit in which the lamp has failed.

Up to 32 phases of current detection must be provided to monitor if an entire circuit or all lamps in a circuit have failed, then the signal monitor unit shall place the intersection in the emergency flashing mode of operation.

1602.05.15 Vehicle Detector Functions

The Controller shall provide a minimum of 64 vehicle detector inputs. Each input shall be assignable to one or more phases and be configured with optional detector functions. Extend and delay timing shall be provided for each detector. Each detector shall be capable of operating in a lock or non-lock mode. The Controller shall also be capable of providing 16 pedestrian detector inputs. Each pedestrian detector shall be assignable to one or more phases.

The Controller shall provide detector cross switching, permitting a vehicle detector to alternately place calls on assigned phases and assigned cross switch phases. If the assigned phase is not green and the cross-switch phase is green, the detector shall place calls on the cross switch phase. If the assigned phase is omitted for any reason, the detector shall place calls on the cross switch phase.

Each vehicle detector shall be user-programmable to operate as one of the following 4 detector types:

- Type 0 (zero): supports all NTCIP or standard detector functionality.
- Type 1: (GREEN DELAY) the first detection received when the phase goes green is recognized irnmediately, whether the detector is active when green starts or is activated after the green is timing. Detections received before the first timeout of the extension interval are also recognized immediately. Once the detector extension interval (not the phase extension interval) times out, all further detector inputs are recognized only if continuously present for a period equal to the programmed delay time AND the delayed signal is NOT extended. The first detection received when the phase goes green, whether present when green starts or received later, is recognized immediately. Detections received before the first timeout of the extension interval are also recognized immediately. Once the detector extension interval (not the phase extension interval) times out, all further detector inputs are recognized only if continuously present for a period equal to the programmed delay time AND the delayed signal is NOT extended.
- Type 2: (STOP BAR WITH EXTEND TIME AND RESET) The detector input must be true when assigned phase green starts else the detector is disconnected for the balance of phase green. If the detector input is true when phase green starts the extension timer is reset while the input remains true. When the detector input is removed the extension timer begins running. If another detector input is received before extension time expires, the extension timer is reset for the duration of the input and once again begins timing when the input goes false. This action is repeated until the extension timer times out. at which time it is disconnected for the balance of phase green.
- Type 3: (RED EXTENSION DETECTION) An actuation on a type 3 detector during the red clearance of the assigned phase shall extend the red up to the red max phase time.

Each detector input shall be capable of functioning as one of 16 system detectors. Vehicle detectors shall be capable of being assigned to a minimum of 16 speed detectors. Speed shall be detected using both one and two detector configurations. Speed shall be computed using a keyboard entered average vehicle length and loop length for a one-detector configuration. When using two detectors, speed shall be calculated using a keyboard entered distance between detectors and travel time between detectors.

1602.05.16 Vehicle Detector Diagnostics and Logging

Time-of-day controlled detectors diagnostics shall be provided that allow testing vehicle and pedestrian detectors for no activity, maximum presence, and erratic output.

A minimum of four detector diagnostic plans shall be provided. These plans shall be selectable on a time-of-day basis. This shall allow varying the detector diagnostic intervals to correspond with changes in detector activity.

If a detector is diagnosed as failed, the associated phase shall be placed in one of the following keyboard selectable modes:

Detector fail recall from 1 to 255 seconds

Disable the detector from calling or extending.

The Controller shall be capable of logging and reporting detector activity, detector failures, and the occurrence of selected events or alarms. Logs shall be capable of being printed or displayed on the front of the Controller.

The Controller shall include a detector log buffer capable of logging volume, occupancy and average speed for selected vehicle and speed detectors.

The detector-logging interval shall be keyboard selectable as 5, 15, 30, or 60 minutes.

Detector logging shall be capable of being enabled or disabled by time-of-day.

The Controller shall include a detector failure log buffer capable of storing a minimum of 100 time and date-stamped detector failure events. Once logged, detector failure events shall remain in the log until cleared or the log buffer capacity is exceeded at which time the oldest detector failure events shall be overwritten.

All detector diagnostic failures shall be recorded in the detector failure log including: no activity, maximum presence, erratic output, watchdog failure, open loop, shorted loop, and excessive inductance change. If a detector recovers after a diagnostic failure, a detector on-line event shall be stored in the detector failure log.

Detector failure logging shall be capable of being disabled.

1602.05.17 Signal Lamp Dimming

The Controller shall provide dimming for selectable load switch outputs. Dimming shall be accomplished by inhibiting the selected outputs for alternate half cycles of the 120 VAC line. Dimming shall be controllable by time of day and an external input; both functions must be TRUE for dimming to occur. Programming shall permit individual dimming of the Green/Walk, Yellow/Ped Clear, Red/Don't Walk outputs for each load switch.

1602.05.18 Conflict Monitor Unit

The Conflict Monitor Unit (CMU) shall be an enhanced version meeting the California Department of Transportation Specifications (TEES)..

When the conflict monitor has detected a conflict, the unit shall require a manual reset prior to resumption of normal operation. A simple method of testing the operation of this unit shall be provided. The Sub-contractor shall describe the proposed conflict monitor and the method of testing its operation.

The CMU is housed in the PDA. There should only be one of these installed in each cabinet. It is the main processor unit of the cabinet monitoring system. It monitors main cabinet functions, such as the condition of cabinet power, door status and status of the flasher. It communicates with the AMUs located in the output assemblies and compares requested actions (from the Controller) with the actual cabinet operation (switch pack outputs) to detect errors, conflicts and other anomalies. It can then direct the cabinet to a flashing or fail-safe condition.

The configuration and operational characteristics of the CMU is determined by software. This programming may be customized to user needs and desires. There is also a specific reporting format in order to address the minimum mandatory functionality of this unit. The minimum functionality is at least that provided by the NEMA TS-2 malfunction monitoring unit.

The unit shall have a serial memory key that contains all information to configure the monitoring system as well as other cabinet configuration information.

1602.05.18.1 Operational Features

A red, yellow, and Green LED for each channel.

Alphanumeric display for event information including time, date, temperature, and line voltage.

Programmable from a PC or manually from the front panel.

Time, Temperature, and line voltage stamped event log 140 event log 140 events deep.

RS-232 and RS-485 serial ports (isolated) for Controller or other communications.

Stop timing signal communications with the Controller.

Immune to out of phase or distorted signals.

No Adjustments.

Enhanced functions selectable on a per channel basis.

1602.05.18.2 Monitoring Features

Detects lack of an output for a particular channel.

Minimum yellow time violations.

Detects multiple outputs on a channel.

Brown out recovery selection.

Monitors positive and negative half waves.

A true RMS value for the voltage on each signal pin.

Software to program the unit shall be supplied.

The conflict monitor unit shall have a warranty period of two (2) years from time of installation and all software upgrades shall be offered at no expense.

1602.05.19 Interval Sequence

Controller timing intervals shall be programmable from 0-255 in one second increments or from 0-25.5 in one-tenth second increments, depending on the function. Four independent timing plans shall be provided. Any plan shall be selectable on a time-of-day basis, by coordination pattern or for one cycle following Pre-emption. Each timing plan shall contain the following interval timings:

Minimum Green	Dynamic Maximum
Delay Green Dynamic	Maximum Step
Conditional Service	Yellow Clearance
Walk	Red Clearance
Walk2	Red Maximum
Walk Maximum	Red Revert
Pedestrian Clearance	Actuations before Reduction
Pedestrian Clearance 2	Seconds per Actuation
Pedestrian Clearance Maximum	Maximum Initial
Pedestrian Carryover	Time before Reduction
Vehicle Extension	Cars Waiting
Vehicle Extension 2	Time to Reduce
Maximum 1	Min Gap
Maximum 2	Steps to Reduce
Maximum 3	

The bike green interval shall replace the phase minimum green if the interval time is larger than the min green time and if a detector input designated as a bike detector has been activated.

Two Walk and Pedestrian Clearance intervals shall be provided for each phase per timing plan. The second Walk and Pedestrian Clearance shall be activated by a time base action plan.

Two vehicle extension intervals shall be provided for each phase per timing plan. The active vehicle extension interval shall be selected by a time base action plan.

If enabled, a Delay Green timer shall delay the vehicle phase from starting until the timer has expired. This shall provide an additional all red for the vehicles movement and allow the pedestrian indications to precede the vehicle movement.

The Pedestrian Walk interval shall extend from Walk to the smaller of the Walk Max time or the phase maximum in effect with a constant input from the "Walk Extension detector".

Volume density intervals shall include actuations before and cars waiting. Actuations before added shall provide a user-specified number of actuations that must occur before adding variable (added) initial time. Cars waiting shall provide a user specified number of actuations, or cars waiting, that must occur before starting gap reduction. Gap reduction shall be initiated by either time before reduction or cars waiting, whichever reaches its maximum value first.

The Controller shall be capable of dynamically extending the maximum green time for each phase based on vehicle demand. Three maximum green intervals shall be selectable per phase based on time-of-day, coordination pattern or external input. The initial interval shall be selectable as Max 1, Max 2, or Max 3. If the phase terminates due to max-out for two successive cycles, then the maximum green time in effect shall automatically be extended by a dynamic max step interval on each successive cycle until it is equal to dynamic maximum. If the phase gaps out for two successive cycles, then the maximum green time shall be reduced by the dynamic max step time until it reaches to the original max value.

Each phase shall have a red maximum timing interval. An input (red extension) shall extend the all red period of the assigned phase as long as the detector input is true. This input must be true within the all red time of the assigned phase to be able to extend the all red period. If this detector fails then the all red extension feature shall be disabled.

Guaranteed minimum interval values shall be settable and shall not be overridden by the Controller. Values shall be provided for the following intervals:

Minimum green
Walk
Pedestrian clearance
Yellow clearance
Red clearance
Overlap Green

If at the end of the terminating stage, neither vehicle nor pedestrian memory indicates a need for the next traffic stage, that stage shall be omitted from the sequence, except where the Drawings indicate that this stage shall not be omitted.

Programming shall be provided to inhibit re-service of odd phases (left turns) within the same concurrent group. Also, programming shall be provided to place a demand on a phase in another concurrent group to cause the Controller to leave the concurrent group prior to servicing the odd phases in the same concurrent group.

The Controller shall provide a programmable simultaneous gap termination feature. When programmed, phases in both rings shall gap out together in order to terminate the green interval and cross the barrier.

1602.05.20 Phase/Stage Relationships

Phases may be assigned to any stage in accordance with local requirements and means shall be provided to allow the phase\stage conflict table to be changed, as needed. Any limitations on the assignments of phases to stages shall be indicated by the Sub-contractor in his proposal.

The Sub-contractor shall provide all equipment, including PROM programmers, download cables, etc. and software to allow the user to modify intersection configuration data, including phase\stage relationship, minimum or maximum timing values, local detector calling and extension functions, etc., in a convenient manner.

1602.05.21 Number of Phases

The Controller shall provide all actuated control functions and operations required by the NEMA TS2 Standard. In addition, it shall provide the features described in the following paragraphs.

The phase sequence of the Controller shall be programmable in any combination of sixteen phases, using up to 16 concurrent groups and four timing rings. Up to 16 unique phase sequences shall be user configurable and used in the Controller. Four additional fixed sequences shall conform to the following TxDOT (Texas Department of Transportation) "Diamond" configurations.

3-phase diamond.
4-phase diamond.
NEMA 8-phase diamond.
2 intersection diamond control.

Phase sequence information shall be changeable from the keyboard and stored in data memory.

The Controller shall provide guaranteed passage operation on a per phase basis. When selected, this feature shall provide a full passage (vehicle extension) interval when a phase gaps out with a gap in effect less than the vehicle extension interval (preset gap).

The Controller shall provide both single and dual entry operation. When selected, dual entry shall cause the Controller to ensure that one phase is timing in each ring.

It shall be possible via keyboard selection to inhibit the service of a phase with other phase(s) within the same concurrent group.

The above should be done by programming to select any combination of phases as in BITRAN program # 2033 or equivalent.

All Controllers housings shall have back wiring for the maximum number of phases. The Sub-contractor shall describe what steps are necessary to expand Controllers to their maximum configuration and what limitations, if any, might be applicable to the use of the phases at this maximum configuration.

1602.05.22 Stage Sequences

The phases of a signal Controller shall be assigned to stages and the sequencing of stages shall be in conformance with the charts and diagrams contained in the Drawings. The stage sequence may be preset as with a Pretimed Controller or variable as with a vehicle Actuated Controller. It shall be possible for the user to specify fixed interval sequences and prohibited sequences with a Vehicle Actuated Controller. Each Controller shall be capable of having its stage sequence selected through central computer control. It shall be possible to select any desired sequence of stages without reference to the preferred or preset sequences. Controller stage and interval sequence circuitry shall however be designed so that computer commands cannot alter fixed interval sequences or user prohibited stage change sequences.

1602.05.23 Basic Interval Setting and Controls

The Controller shall provide for the setting of each interval, portion of interval, or function by a positive setting on a calibrated control or other equivalent means. The setting of all intervals shall be adequately protected against inadvertent or unauthorised adjustment. It shall be possible to adjust all intervals without causing a break in signal operation.

An integral keypad and associated display shall be provided on the front panel of the Controller for setting the timing of each interval or period, as well as each programmable parameter. The keyboard display shall identify (echo) each key touches (activated).

The front panel of the Controller shall have displays to indicate the operational status for all phases and stages as well as all sequence, timing and operation parameters. (See Clause 1602.01of these Specifications for displays description).

All display indicators shall have a minimum design life of 20,000 hours at rated voltage and shall be easily accessible to permit replacement All displays shall be clearly discernible in direct sunlight from a distance of at least one meter.

1602.05.24 Start-up Sequence

Upon connection of power or resumption of power following an interruption of sufficient duration to cause the Controller to shut down, the Controller shall begin operation in Flashing Mode. This mode shall have a duration selectable from 5 to 20 seconds. The Flashing Mode shall be followed by all-red period of 5 seconds and this shall in turn be followed by display of main road green. The main road green stage or phase shall be user selectable from the available stages or phases. The Controller shall at this point resume normal operation.

1602.05.25 Computer Control Inhibit Facility

A switch or other suitable alternative means shall be provided which, when asserted, shall prevent the Controller from responding to commands from the central computer.

1602.05.26 Additional Functions

The Controller shall be capable of providing additional traffic control functions. Additional capabilities which shall be provided by the Local Controller include, but are not limited to, the following:

- Conditional Service;
- All red extensions;
- Volume density operation conforming to NEMA Standards TS-1-1989 or TS-2-1998 or approved equivalent;
- Parallel stage streaming conforming to UK Department of Transport Specifications MC 0141,1984, latest revision or approved equivalent;
- Pedestrian recall;
- Vehicle Recall for Minimum Green Interval;
- Vehicle Recall for Maximum Green Interval;
- Vehicle detector Memory Circuit enable;
- Vehicle Detector Memory Circuit disable;
- Soft Recall
- No-rest phase
- Enable Added Initial and
- Special Facility Control

1602.05.26.1 Logic Functions

One Hundred (100) logic processor commands shall be accessable from the front panel of the Controller or through remote database management software. Each logic command shall be allowed to be enabled or disabled by time-of-day control.

Each logic command shall consist of ten "IF" statements, five "THEN" statements and five "ELSE" statements. At least one "IF" statement and one "THEN" statement are required to create a valid command.

"IF" statements shall be logically grouped using boolean gating including:

- AND
- OR
- XOR
- NAND
- NOR

When combined "IF" statements create one single "TRUE" result, the "THEN" statements shall be implemented.

When combined "IF" statements create one single "FALSE" result, the "ELSE" statements shall be implemented.

The "IF" statements shall monitor Controller functions and timer including, but not limited to the following:

Phase/Overlap Green	Phase Calls
Phase/Overlap Yellow	Phase Omits
Phase/Overlap Red	Phase Force Offs
Phase/Overlap Active	Detector Fails
Detector Plan Number	Ring Timers
Detector Activity	Pre-emption Activity
Detector Volume	Pre-emption Dwell
Detector Occupancy	Pre-emption Exit
Coordination Timers	Stop Time
Coordination Holds	Manual Control
Phase Holds	Overlap timers (lagging/leading)
Phase Walks	Active Coordination Plan Number

Phase Don't Walks TBC parameter
Phase Nexts Input / Output Bits
Phase Checks Logic Flags

The "THEN" and "ELSE" statements shall be used to control functions and events (on/off) in the Controller, including, but not limited to, the following:

Set Logic Flags
Set Phase/OVL Greens
Set Phase calls
Set Phase/OVL Yellows
Set Input or Output Bits
Set Phase/OVL Reds
Set Delays
Set Walk I Ped
Clear I Don't Walk
Set Load Switch circuits (RlY/G)
Set Pedestrian Detectors
Set Vehicle Detectors
Set Holds Omit Phase I Peds
Set Force-offs
Change Max Timers (max1, max 2)
Set Red Rest
Set Stop Time
Set Flash
Set Alarms
Set External Start
Set Recalls, CNA 1, CNA2, etc
Set Manual Control Enable
Set Coordination Plan
Set Manual Advance
Set Free Call Preempt Call TSP Call Phase

An additional one-hundred logic commands (101-200) shall be available in the Controller, but hidden from front panel access. These commands shall be stored and used for easy implementation of common logic required at multiple intersections.

These commands shall only be assessable through computer software and shall be uploaded and downloaded to the Controller using the same computer software. Once downloaded to the Controller, the logic shall be activated using an extended options file. This file shall be downloaded to the Controller and used to initialize the logic statements. This file shall be used to create a custom menu on the Controller. From this menu the user shall be able to enable or disable any of the extended options hidden in the upper one hundred logic commands.

1602.05.27 Pedestrian Functions

The Controller shall provide the following selectable pedestrian functions:

Pedestrian Recall
Exclusive Pedestrian Phase
Actuated phase rest in WALK
Flashing WALK output
Pedestrian clearance protection during manual control
Pedestrian clearance through yellow

Pedestrian indications remain dark with no call

Pedestrian timing shall be capable of being carried over from one phase to another

1602.05.28 Flashing of Signals

The Controller shall provide automatic flash selection per the requirements of the MUTCD (Manual on Uniform Traffic Control Devices for Streets and Highways). Both the flash entrance and exit phases shall be programmable through the keyboard, and flashing shall be controlled by either setting the fault/voltage monitor output to be FALSE or by flashing through the load switch driver outputs. If flash desired through the load switches, both the phase and overlap outputs shall be flashed either yellow or red as selected by the operator. Automatic flash shall be selectable by external input, system command, or time of day action plan.

The flashing of signal indications shall be possible even with the local Controller removed from the housing.

Flashing shall be at a rate of between 50 and 75 flashes per minute and the lamps shall be illuminated for between 50% and 65% of the time.

The flashing mode shall provide for the flashing of the red vehicular signals. A simple means must be available to change the selection of colors to be flashed on different Controller phases.

1602.05.29 Asynchronous Modem Serial Communications Module

1602.05.29.1 Power and Circuit Requirements

Power shall be a fused isolated +5 VDC with a minimum of 100 mA power supply provided for external use.

Two circuits, designated CIRCUIT #1 and CIRCUIT #2, shall be provided. Both circuit functions shall be identical, except for their Serial Communications Port and external connector (CIRCUIT #1 to SP1 [or SP3] and C2S Connector and CIRCUIT #2 to SP2 [or SP4] and C20S Connector).

The Circuits shall convert the Controller Motherboard SP EIA-485 signals to/from board TTL level signals, isolate and drive the converted EIA-232 Signals interfacing with their associated MODEM and external connector.

1602.05.29.2 Modem Requirements

Each CIRCUIT shall have a MODEM with the following requirements:

Data Rate: Baud modulation of 0 to 9600.

Modulation: Phase coherent frequency shift keying.

Data Format: Asynchronous, serial by bit.

Line & Signal Requirements: Type 3002 voice-grade, unconditioned Tone Carrier Frequencies (Transmit and Receive): 11.2 KHz MARK and 17.6 KHz SPACE, ±1 % tolerance. The operating band shall be (half power, -3 dB) between 9.9 KHz & 18.9 KHz.

Transmitting Output Signal Level: 0, -2, -4, -6, and -8 dB (at 14.7 KHz) continuous or switch selectable) Receiver Input Sensitivity: 0 to -40 dB.

Receiver Bandpass Filter: Shall meet the error rate requirement specified below and shall provide 20 dB/octave, minimum active attenuation for all frequencies outside the operating band.

Clear-to-Send (CTS) Delay: 11 ±3 ms.

Receive Line Signal Detect Time: 8 ±2 ms mark frequency.

Receive Line Squelch: 6.5 (±1) ms, 0 ms (OUT).

Soft Carrier Turn Off Time: 10 ±2 ms (7.8 KHz). When the RTS is unasserted, the carrier shall turn off or go to soft carrier frequency.

Modem Recovery Timer: Capable of receiving data within 22 ms after completion of transmission.

Error Rate: Shall not exceed 1 bit in 100 Kbits, with a signal-tonoise ratio of 16 dB measured with flat-weight over a 3QQ to 3,000 Hz band.

Transmit Noise: Less than -50 dB across 600-ohms resistive load within the frequency spectrum of 300 to 3,000 Hz at maximum output.

Modem interface: EIA-232 Standards.

Two LOGIC switches per circuit shall be provided (faceplate mounted). One shall be used to vertically switch between Half-Duplex (Down) and Full-Duplex (Up). In Half-Duplex mode, the Transmit connections shall be used for both Receive and Transmit.

A MODEM Enable switch shall be provided that when in the UP Position shall enable MODEM and disable MODEM in the DOWN Position.

A CONTROL switch shall be provided on the module front panel to turn ON (Up) / OFF (Down) all module power.

1602.06 OPERATIONAL FEATURES FOR PEDESTRIAN CONTROLLED SIGNALISED CROSSINGS

1602.06.1 Flashing Rate

The flashing rate of the green pedestrian signal shall be in the range 75 to 85 flashes per minute and the aspect shall be illuminated for 45% to 55% of the time.

1602.06.2 Pedestrian Detectors (Push Button)

All installations push buttons, as described in Clause 1604.01of these Specifications, shall be provided. Operation of the push button in period D, E of F of the signal sequence shall register within the Controller a demand for the pedestrian stage and shall cause lamps within all the push button boxes associated with the installation to be illuminated thus causing their ‘WAIT’ panels, as described in Clause 1604.01.4 of these Specifications, to be displayed. The lamps shall remain illuminated until the end of period B, when they shall extinguish.

1602.06.3 Audible Signal

Unless otherwise specified, an audible signal for pedestrians shall be provided within one push button box on each footway. The fundamental frequency of sound emitted shall be between 2.0 kHz and 3.5 kHz and it shall be pulsed at 240 ppm + 60 ppm, having an on/off ratio of 1.5:1 +10%. A mechanical means shall be provided in the push button box for adjusting the intensity of the sound.

The audible signal shall operate only during period C as defined in Table 1602.03.

1602.06.4 Vehicle Actuated Operation

Where Vehicle Detectors are shown on the Drawings, Vehicle Actuated Operation shall apply. The Vehicle Running Period shall consist of three elements as shown in Table 1602.06.4. After the expiry of the Minimum Running Period, timed from the commencement of period F, any vehicle passing over the Vehicle Detector Loops shall extend the Vehicle Running Period.

Period	Range (sec)	Interval (sec)
Minimum Running Period	6 to 15	1
Vehicle Extension	1.5 to 4	0.5
Maximum Running Period	10 to 60	10

Table 1602.06.4 Vehicle Running Period

If a pedestrian demand has been received in period E and stored, timing of the Maximum Running Period shall commence at the end of period E. If the demand is received during period F, timing shall commence on receipt.

Detection of vehicles passing over the loops may extend the Vehicle Running Period up to the Maximum Running Period, upon which the sequence of signal operation shall commence.

If during the Maximum Running Period, but after the expiry of the Minimum Running Period, no further vehicle extensions are registered the sequence of signal operation shall then commence.

Means shall be provided within the Controller so that the duration of each element of the Vehicle Running Period may easily be adjusted.

1602.06.5 Detector Fault Monitor

Model 2070 Controller shall incorporate a Detector Fault Monitor that shall be capable of determining when there has been no change in output from one or more of the Vehicle Detector Loops during a pre-set time period. This period shall be 9 or 18 hours, as specified, and when exceeded, the detector shall be deemed to be faulty.

When this condition exists, a Detector Fault Monitor Lamp mounted on the exterior of the cabinet, shall be illuminated. This lamp shall be coloured red and be of such intensity as to be readily visible in bright sunlight. It shall be extinguished only by the operation of a manual re-set switch located within the interior of the cabinet. It shall be possible for the monitor to provide information for transmission to the central computer.

1602.06.6 Fixed Vehicle Period Operation

Where no Vehicle Detectors are shown on the Drawings, a fixed Vehicle Running Period shall operate. It shall be fixed in the range 20 to 60 seconds, with step size of 4 seconds and timing shall commence at the end of period E. Demands received during period E or F shall be stored and the sequence of signal operation shall commence at the end of the Fixed Vehicle Period, or immediately if this period has already expired.

1602.06.7 Signal Conflict Inhibitor

Means shall be provided within the conflict monitor to prevent the following:

a. The display of a green signal, whether steady or flashing, to pedestrians without a red signal being displayed to vehicles.
b. The operation of the audible signal at any time except period C.

1602.06.8 Red Lamp Failure Monitor

The conflict monitor shall be capable of monitoring the illumination of all red aspects of the signals to vehicles. Should it detect that during the duration of the red signal to vehicles that all red aspects on any one approach are extinguished, due to lamp failure or any other condition, the conflict monitor shall within 0.5 second switch off all signal lamps, WAIT indicator lamps and/or audible signals. The installation shall remain in this condition until the conflict monitor is reset by means of a non-locking manual re-set switch within the cabinet. The start-up procedure shall be as specified in Clause 1602.06.10 of these Specifications.

1602.06.9 Mains Failure

In the event of an interruption to the mains supply of not more than 50 milliseconds, the Controller shall continue to function correctly. Where a shut down due to an interruption of more than 50 milliseconds occurs, the Controller shall remain shut down until the mains supply is restored. The start-up procedure shall be as specified in Clause 1602.06.10 of these Specifications.

1602.06.10 Start-up Procedure

When a Controller is brought into, or restored to, operation, the signal cycle shall commence at the beginning of the Vehicle Running Period, with a pedestrian demand stored. The cycle shall then continue as previously specified.

1602.06.11 Manual Facilities

The following facilities shall be provided on an easily accessible panel mounted within the cabinet:

a. A single locking switch be means of which the signals may be connected to, or disconnected from, the Controller. Upon disconnection of the signals, the Controller shall continue to function correctly. Upon connection, or reconnection, of the signals the start-up procedure shall be followed.
b. A single locking switch that shall generate a continuous pedestrian demand.

Additionally at Vehicle Actuated Controllers,

c. A non-locking switch, which shall generate a single vehicle extension and inhibit extensions generated by the Vehicle Detectors whilst it is depressed. An indicator lamp shall be positioned adjacent to this switch and shall be illuminated for the period of the vehicle extension, when the test switch is operated.
d. A single locking switch that shall generate a continuous vehicle extension.
e. A non-locking switch that shall cause the Detector Fault Monitor Lamp to be illuminated without otherwise interfering with the detector fault monitor operation.
f. A non-locking switch by means of which the Detector Fault Monitoring equipment and indicator lamp may be reset. However, operation of this switch shall have no effect if the fault condition persists.

Should the facilities described in paragraphs (c) and (f) be provided at a Controller operating with a Fixed Vehicle Period, then the switches shall have no effect.

1602.07 OPERATIONAL FEATURES FOR ALTERNATE FLASHING LIGHT SIGNAL INSTALLATIONS

1602.07.1 Flashing Rate

The rate of flashing of the red Alternate Flashing Light signals shall be in the range of 75 to 85 flashes per minute and each aspect shall be illuminated for 45% to 55% of the time. At no time during operation shall both aspects as dark.

1602.07.2 Emergency Push Button Box

The Controller shall normally be mounted within this cabinet. The following facilities shall be provided:

A top panel shall include lamps to indicate the signals being shown to Emergency Vehicles (s) during the operating sequence. Normally this will require one yellow lamp over one green lamp, centred horizontally within the panel, but in the case of dual carriageway operation and where both call out buttons are mounted in the same box, two yellow lamps shall be positioned over two green lamps such that each pair of one yellow and one green lamp is equi-distant from the central vertical line.

A bottom panel shall include:

a. The Emergency Detector(s) - which shall be one (or two) push button(s) centred horizontally and clearly marked. In the case of dual carriageway operation the buttons shall be of different colours.
b. A Mains Electricity Supply Monitor Lamp – this shall be a long life clear incandescent or red neon lamp. The operation of this monitor shall be as described in Clause 1602.07.3 of these Specifications.
c. A Red Signal Monitor Lamp – this shall be a long life clear or green lamp. The operation of this monitor shall be as described in Clause 1602.07.4 of these Specifications.
d. The Audible Alarm Switch – a two position switch shall be provided. Its upper position shall be the ‘normal’ position and its lower position, the ‘cancel’ position.
e. Emergency Detector Monitor Lamp(s) – which shall be provided in the case where operation of the Emergency Detector(s), when the Controller is in the quiescent state, will initiate a single or double timer within the Controller. Long life yellow lamps(s) shall be used, the operation of which shall be as described in Clause 1602.07.5 of these Specifications. The lamp(s) shall be mounted adjacent to the Emergency Detector to which it refers.

Each of the above shall be clearly labelled.

The layout of the top and bottom panels shall be approved by the MOI/Engineer.

Within, or adjacent to, the Emergency Push Button Box shall be the audible alarm. There shall be two sources of electricity supply, namely a mains derived supply to operate in the case of a red signal lamp failure and a primary cell supply to operate in the case of a mains supply failure. The cells shall be capable of operating the alarm continuously for not less than 4 hours before replacement. The fundamental frequency of sound emitted by the alarm shall be between 2.5 kHz and 3.0 kHz and it shall be pulsed at 240 ppm +60 ppm and have an on/off ratio of 1.5:1 ± 10%.

1602.07.3 Mains Failure Alarm

In the event of a mains failure, as defined in Clause 1602.08.5 of these Specifications, the audible alarm shall start to operate and the monitor lamp be extinguished. The alarm shall be silenced by moving the alarm switch to the 'cancel' position. When the mains supply is restored the alarm shall again sound until the alarm switch is returned to the 'normal' position. Should the supply be restored before the switch has been moved to the 'cancel' position, the alarm shall cease and the Controller return to the idle state. In either case the monitor lamp shall illuminate. If the Emergency Detector is operated whilst the alarm switches are in the 'cancel' position, the alarm shall sound whilst the button is pressed. If, during a mains failure, the alarm switch is moved to the 'normal' position the alarm shall sound until the switch is returned to the 'cancel' position.

The operation of the Emergency Detector and the normal operation of the Controller shall not be inhibited by the position of the alarm switch provided that mains power is on and no red signal lamp failure is indicated.

1602.07.4 Red Signal Lamp Failure Alarm

It shall not be possible to display the green signal(s) to the emergency vehicle(s) unless all the red Alternate Flashing Light signals displayed to traffic on the highway are functioning correctly. This shall be monitored by checking either that the red Alternate Flashing Light signal lamp current is being drawn or that the red Alternate Flashing Light lamps are being illuminated.

In the event of one or more red Alternate Flashing Light lamps failing, the red signal monitor lamp shall be extinguished and the alarm shall sound. The alarm shall be silenced by moving the alarm switch to the 'cancel' position.

The lamp failure detection circuitry shall operate a manually resettable, mechanical trip, mounted within the Controller cabinet, which shall prevent further signal indications being given to the Emergency Vehicle(s) but shall allow the normal sequence (as modified by the failed lamp(s)) to appear on the highway. This mechanical trip shall not be affected by mains switch-on, failure or restoration.

When the mechanical trip is reset, the red signal monitor lamp shall be illuminated and the alarm shall sound until the alarm switch is moved to the 'normal' position. If the switch is moved prior to the trip being reset, the alarm shall sound until the switch is returned to the "cancel' position. The alarm shall also sound if the Emergency Detector is pressed whilst the switch is in the 'cancel' position and shall continue to sound until the button is released.

If a mains supply failure occurs when the mechanical trip is in the operated state and the alarm switch is in the 'cancel' position, the alarm shall remain silent.

1602.07.5 Emergency Detector Monitor Lamp(s)

When the operation of the Emergency Detector(s) occurs such that a delay timer is initiated or during a period, in a previously initiated signal sequence, where a demand is then stored, the Emergency Detector Monitor Lamp(s) shall be caused to illuminate. The lamp(s) shall be extinguished upon commencement of the next sequence of Alternate Flashing Light signal operation.

1602.07.6 Manual Facilities

A single locking switch shall be provided within the Controller cabinet which shall enable the signal lamps to be connected to or disconnected from the Controller.

1602.08 ELECTRICAL

1602.08.1 Power Supply

Power will be provided to the Controller by the Ministry of Electricity and Water and the provisions of Clause 1601.02 of these Specifications shall apply.

1602.08.2 Battery Backup System (BBS)

The Traffic Signal Battery Backup System (BBS) shall provide uninterruptible reliable emergency power to a traffic intersection in the event of a power failure or interruption. The uninterruptible power supply (UPS) shall provide battery power to traffic intersections for a period of 2 hours. The transfer from utility power to battery

power will not interfere with the normal operations of the traffic Controller, conflict monitor or other devices within the traffic control cabinet. The BBS / UPS system shall be comprised as noted below and shall include, but not be limited to: Inverter/Charger/Controller (UPS Controller), power transfer switch (PTS), batteries, a separate non-electronic manual bypass switch (MBS), all necessary hardware and interconnect wiring

The system shall be capable of providing power for full run-time operation, flashing mode operation, or a combination of both full and flash mode operation of an intersection. The signal from the UPS Controller to the traffic signal system to start flash mode shall be field programmable to activate at various times or remaining battery capacities.

The system shall be capable of providing power for full run-time operation, flashing mode operation, or a combination of both full and flash mode operation of an intersection. The signal from the UPS Controller to the traffic signal system to start flash mode shall be field programmable to activate at various times or remaining battery capacities.

Field programmability via touch pad or computer interface must be in user friendly, menu driven formats and must not require any external or proprietary software. Communications (com) ports shall include a DB-9 connector for RS-232 interface and USB port, or optional Ethernet port, installed on the front panel of the UPS Controller.

The system shall be designed for outdoor applications and meet the environmental requirements as detailed herein.

1602.08.2.1 System Capacity and Runtimes

The BBS shall be configured such that it provides a minimum of two (2) hours of full run-time operation for an intersection using LED and/or incandescent traffic and pedestrian signals. The UPS Controller shall be rated at 2000 VA /1500 Watts with 80% minimum inverter efficiency. The actual load and desired back-up run time at any given intersection will determine battery sizing.

1602.08.2.2 Relay Contacts

The UPS Controller shall provide the user with 6 sets of N/O N/C panel-mounted, potential free, fully programmable relay contacts rated 1 Amp, 240 VAC and labeled C1 through C6. Each relay's setting shall be programmable to activate under any number of conditions locally using the touch pad or remotely using the com port interface. Relay contacts C1 through C6 can be independently configured to activate under any of the following conditions:

ON BATTERY - relay activates when BBS switches to battery power.

LOW BATTERY - relay activates when batteries have reached a certain level of remaining useful capacity while on battery power. This number is adjustable from 42 to 55 VDC representing 0 to 100% of useable battery capacity.

TIMER-relay activates after being on battery power for a given amount of time. This number is adjustable from 0 to 8 hours.

ALARM-relay activates after a specific or general alarm is detected. These alarm conditions include: line frequency, low output voltage, no temperature probe, overload, batteries not connected, high temperature, and low temperature. The relay can be programmed to activate when any of these alarm conditions are met, or when a specific condition is met.

FAULT·relay activates after a specific or general fault is detected. These fault conditions include: short circuit, low battery voltage, high battery voltage, high internal temperature, and excessive overload. The relay can be programmed to activate when any of these fault conditions is met, or when a specific condition is met.

OFF-relay is disabled and will not activate under any condition.

Default Relay Settings

Relay C1 shall be set to activate whenever the UPS Controller transfers to battery power and shall be labeled "ON BATT".

Relays C2 and C3 shall be set to activate whenever the batteries reach 47.5 VDC representing 40% of remaining useful capacity and shall be labeled "LOW BATT".

Relays C4 and C5 shall be set to activate whenever the UPS Controller has been on battery power for 2 hours and shall be labeled "TIMER".

Relay C6 shall be set to activate whenever the UPS Controller has an active alarm.

Terminal Block positions 19 & 20 shall be set to activate a self test. This test confirms that a unit can transfer into and out of battery mode while supporting the output load.

1602.08.2.3 Operation

The Manual Bypass Switch (MBS) shall be rated at 240VAC, 30 Amps minimum.

The MBS shall completely remove power to the UPS to allow repair or replacement without having to interrupt power to the intersection. The MBS and Power Transfer Switch (PTS) shall be separate units allowing for the replacement of the PTS without interrupting power to the intersection.

The BBS shall use a temperature-compensated battery charging system. The charging system shall compensate over a wide range of at least -2.5 to -5 mV / °C / Cell. The charger shall be rated 10 Amps at 48VDC.

The temperature sensor shall be external to the UPS Controller unit. The sensor output will be used to regulate the charge rate at high ambient cabinet temperature

Batteries shall not be charged when battery temperature exceeds 50°C ± 3°C.

The UPS Controller shall have operating voltages of 240 VAC and frequency of 50 Hz that is set at initial startup using the com port interface.

When using battery power (inverter mode), the BBS output voltage shall be 240 VAC +/-5%, pure sine wave output with THO < 3% at 50 Hz +/-3 Hz.

In the event of UPS Controller failure, battery failure or complete battery discharge, the Power Transfer Switch shall revert to the Utility or Line Mode (in a de-energized state) where utility power is supplying the cabinet.

1602.08.2.4 Environmental

The operating temperature for the Inverter/Charger/Controller (UPS Controller) shall be -34°C to +74 °C since it may be installed in the same cabinet as traffic control equipment. The PTS and MBS shall have an operating temperature of at least -20°C to +65 °C.

1602.08.2.5 Product Compatibility

BBS shall be compatible with all of the following for full phase, flash operation mode or a combination of both full and flash mode operation:

Type 336 Cabinets,
Type 170 Controllers,
Type 2070 Controllers,

The BBS shall fit inside an auxiliary 3mm thick Aluminum cabinet.

BBS shall be an approved CALTRANS Qualified Products List (QPL) device.

1602.08.2.6 Loss and Restoration of Utility Power

In the event the BBS senses the utility line voltage is outside the programmable Low or High Limits (219 & 262 VAC +/-2 VAC respectively set as default for 240 VAC systems), the BBS shall transfer the load to. battery power. The BBS must allow the user to change the Low and High limits to suite local power specifications and typical operating voltage at the intersection.

The BBS shall return to line mode when the utility power has been restored to above the programmable value for more than 30 seconds (225 VAC +/-2 VAC set as default for 240 VAC systems). This line qualification time can be adjusted to 3, 10 or 30 seconds locally using the touch pad or remotely using the com port interface.

The BBS shall return to line mode when the utility power has been restored to below the programmable value for more than 30 seconds (256 VAC +/-2 VAC set as default for 240 VAC systems). This line qualification time can be adjusted to 3, 10 or 30 seconds locally using the touch pad or remotely using the com port interface.

The maximum transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from batteries, shall be 65 milliseconds. This transfer time includes operation of both the UPS Controller and Power Transfer Switch. The same maximum allowable transfer time shall also apply when switching from inverter line voltage to utility line voltage.

1602.08.2.7 Back-Feed and Other Protections

The BBS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service per UL 1778, Section 48 "Back-feed “protection Test” The upstream back-feed voltage from BBS system shall be less than 1 Volt AC for the protection of the traffic engineer or technician

The BBS shall have lightning surge protection compliant with IEEE/ANSI C.62.41 for 2000 Volts AC.

1602.08.2.8 Mounting and Configuration

Mounting method shall be shelf-mount, rack-mount, battery swing-tray mount, or combination thereof.

All necessary hardware for mounting (shelves, racks, harness, etc.) shall be included in the bid price of the BBS as required by the application. If battery swingtrays are used, a minimum of 6 bolts/fasteners shall be used to secure it to the 19" cabinet rack.

External Battery Cabinets may be used to meet adequate environmental and physical requirements

External battery cabinets when required must have an option for generator receptacle (Hubbell HBL2625 250VAC 30A 3W L6-30P Inlet White Nylon or equivalent) with lift cover (Hubbell-Bell 5030-0 Generator Inlet Lift Cover 30 & 50 or equivalent) and a generator transfer switch included in the MBS/PTS assembly (Baco R402201 C8EQ72GN60 Switch Cam SPOT On-Off-On 40A 600VAC or equivalent).

1602.08.2.9 Functionality. Displays, Controls. Diagnostics and Maintenance

The BBS shall include an LCD display to indicate current battery charge status, various input/output voltages, power output, battery temperature, date, time and settings of the various field programmable relays. The same parameters shall be available via com port interface for remote monitoring.

The UPS Controller shall provide the power for an external fan located in the same or in a separate battery cabinet. The fan shall activate based on the temperature measured by the temperature sensor placed on the batteries. The temperature setting shall be adjustable from the touch pad or remotely via com port. The temperature range shall be from +20°C to +55°C in 1 degree C increments.

All control, programming, maintenance and inquiry shall be accessible via the keyboard on the face of the BBS without the need for the use of any additional equipment or external PC.

On-Line (Stage 1) BOOST and BUCK modes shall be provided in case of extended power variations. The BBS shall have the ability to BOOST and BUCK by 10 VAC by changing transformer taps without using batteries. BOOST and BUCK can be enabled or disabled.

The PTS shall be activated during BOOST and BUCK operation. The transfer time shall be less than 30 milliseconds typically to meet Controller requirements.

The UPS Controller shall be provided with a re-settable inverter event counter and a cumulative inverter timer that is accessible via the LCD screen or remotely via com port.

The UPS Controller shall be equipped with an event log that stores at a minimum the last 100 events. The events shall be time and date stamped. The event log shall be retrievable via com port or from the BBS LCD screen. The

com port to the PC shall display the events in a text message format with the use of HyperTerminal. The BBS LCD Screen may display the events in a binary message format.

The BBS shall be capable of performing a self test, locally from the UPS Controller front panel LCD, or remotely via com port interface. The duration of the self test shall be programmable in 1-minute increments from 1 to 255 minutes.

The set point for LOW BATTERY ALARM shall be programmable via the com port. The LOW BATTERY programmable contact shall be adjustable from the touch pad or remotely via com port. with incremental adjustment of 0.5VDC

Certain maintenance controls such as Battery Test, BBS inverter ON/OFF, viewing the Event log and changing default settings shall be password protected. The UPS Controller shall be provided with a default password. The user can change the password in order to restrict access to sensitive functions.

The current date and time as well as automatic switching to Daylight Saving, if used, shall be adjustable from the touch pad.

The following LEDs shall be used to indicate current status:

Green LED Flashing battery back-up mode

Green LED Steady ON normal line mode operation

Red LED Flashing ALARM conditions

Red LED Steady ON FAULT conditions

The BBS shall be easily replaced and installed (complete turnkey system with all necessary hardware). The BBS shall not require any special tools for installation.

1602.08.2.10 Battery System

Individual batteries shall be 12VDC type and shall be easily replaced and commercially available off the shelf.

The battery system used in the BBS shall consist of 4 batteries strings and for safety, shall be of a voltage not to exceed 60VDC. Batteries shall be provided with bolted terminals and a polarized keyed battery cable for easy field installation. Battery sizing will be determined by the load and runtime requirements for any given intersection.

Batteries shall be extreme temperature, deep cycle, sealed prismatic lead calcium based AGM VRLA (Absorbent Glass Mat Valve Regulated Lead Acid) batteries.

Regardless of operating temperature rating by battery manufacturer, battery performance changes drastically with temperature and number/depth of discharge cycles. Batteries usually have different temperature ratings for charge and discharge. Batteries lose capacity at cold temperatures and lose useable service life at high temperatures. Batteries shall be capable of charge and discharge over a temperature range of -25°C to +60°C even if at reduced capacity or shortened service life

The batteries shall be provided with appropriate interconnect wiring harness and a corrosion-resistant stationary or swing-out mounting tray and/or brackets appropriate for the cabinet into which they will be installed.

Batteries shall indicate maximum recharge data and recharging cycles.

Recharge time for the battery from protective low cutoff to 80% or more of full battery charge capacity shall not exceed twenty (20) hours under optimal conditions.

The external battery cabinet, shall be vented through the use of louvered vents, filter, and one thermostatically controlled fan operated from the UPS Controller. The Fan will automatically turn on at the temperature programmed into the UPS Controller as measured by the temperature sensor.

1602.08.2.11 Service and Warranty

Manufacturer/local agent shall provide a two (2) year -repair warranty on the BBS.

1602.08.2.12 Specifications

Nominal Input Voltage 240VAC

Single Phase Input Voltage Range 240VAC +/25%

Input Frequency 50 Hz +/-5%

Nominal Output Voltage 240VAC,

Single Phase Power Rating 2000VA (1500 Watts)

Output Frequency 50 Hz (+/-5%)

Voltage Wave Form Sine Wave, THD < 3% Efficiency (line mode) >95% Efficiency (inverter mode) >80%

Inverter / Charger 17" wide (19" w/rack brackets) x 5.25" high (3U) x 11" deep (allow 1" more for cables) MBTS/PTS Assembly 19" wide x 3.5" high (2U) x 8.5" deep Weight under 50 Lbs

1602.08.3 Controller Connections

The Signal Controller shall be connected to the housing terminals in such a manner that the Controller can be removed from the housing without the necessity of disconnecting individual wires. This may be accomplished through the use of multiple pin jacks or other suitable means. The removal of the Controller from the cabinet shall initiate Flashing Mode.

The electrical connections from the Controller to the incoming and outgoing circuits, shall be made in such manner that any unit can be readily replaced with a similar unit, without the necessity of disconnecting individual wires leading therefrom. This shall be accomplished by means of a multi-terminal, screw-secured plug and jack. Appropriate means of entry and support for cables shall also be provided.

1602.08.4 Overcurrent Protection

The Signal Controller and related equipment shall be protected from electrical power supply surges.

1602.08.5 Automatic Reorientation

The Signal Controller shall be capable of automatic re-orientation in the event of a mains supply interruption and the subsequent resumption of power service, as follows:

a. In the event of a mains supply interruption equal to or less than 50 milliseconds, the Controller and associated data transmission equipment, shall continue to function correctly.
b. When the Controller fails due to mains supply interruption in excess of 50 ms, the Controller shall shut down for the duration of the interruption, and subsequently when mains or emergency power is provided, follow the start-up sequence as specified.

1602.08.6 Constancy of Timing

The length of any interval or timing setting shall not change by more than +100 milliseconds of its set value so long as the voltage and frequency of the mains supply remain within the tolerances specified.

1602.08.7 Load Switching Assemblies and Signal Circuits

Three-circuit, solid state load switching assemblies, conforming to NEMA Standards TS-1-1989 or approved alternative shall be provided. Indicator lamps shall be provided in the front panel of each load switch to indicate the state of the input circuit of the load switch. Each load switch shall utilize optical isolation between input and output.

The load switch assemblies shall be suitable for the switching of the anticipated loads as indicated by the stage/phase sequence charts and for the environmental conditions experienced in Kuwait.

The load switches shall provide positive switching of signals without dark intervals, flickering of lights, or conflicting signal indications.

A load bay position shall be provided in the Controller housing for each of the phases. The number of load switching assemblies to be provided will be determined by the number of phases, initial and future, for each intersection.

A signal isolation switch shall be provided to enable the Controller to remain operational without causing any signal aspect to be illuminated.

1602.08.8 Voltage Stabilizer

The voltage stabilizer shall be a machine wound column regulating transformer with the insulation on the outer layer stripped to provide a constant smooth path for voltage tapping.

The roller-shaped collectors shall be made of a special carbon type. The roller holders shall be made of spring bronze with no intermediate links, so that correct roller pressure on the winding shall always be ensured.

The Collector Bridge shall be positioned by means of a gear motor with servo and chain drive.

The motor shall be controlled by an electronic unit mounted in a polystyrene box inside the enclosure.

For protection against short-circuiting and continuous overload, a fuse type NH shall be mounted on the outgoing supply line of the stabilizer.

The automatic voltage stabilizer (AVS) shall be adjusted from the factory with transformation ratio 1:1 it shall be possible to insert the voltage stabilizer in supply line without cutting of the power supply to the critical loads.

The servo-controlled automatic voltage stabilizer

Rated: 5 kVA (p.f. = 0.8)
Input Voltage: 1x240 Vac, 50 Hz, 1-phase
Input Voltage Variation: ±15%
Output Voltage: 1x240 Vac, 1-phase
Output Voltage Variation: ±1% steady state
Protection Class: IP65 for outdoor installation
Cooling: Air natural
Equipped with sunshade for protection against direct sun rays
Equipped with RC filter on the output side.

1602.09 CABINET

1602.09.1 Materials

The cabinets to house Signal Controllers shall be constructed of sheet aluminium (minimum thickness 3 mm) in accordance with NF EN 12368 or approved equal standard, and shall be grey. The MOI/Engineer may authorise the use of a cabinet made of other materials, in which case it shall have characteristics in terms of strength, abrasion resistance and exposure to the elements that are equal to the aluminium cabinet. In the case of a cabinet made of a non-metallic material, it shall have deflection characteristics similar to those of a metallic cabinet and under a horizontal load of 2.2 kN (500 lbs) applied along the upper edge of the cabinet, it shall not deflect by an amount greater than a metal cabinet constructed of 3 mm sheet aluminium in accordance with NF EN 12368. Likewise, when the same load is applied at the midpoint, deflection in the flat surfaces of the cabinet shall not exceed those experienced in the aluminium cabinet of similar size under the same load. Complete details of the cabinet construction shall be submitted by the Sub-contractor to the MOI/Engineer for approval.

1602.09.2 Dimensions

Each Controller cabinet shall be of sufficient size to accommodate the Controller, Vehicle Detector assemblies, cable terminations, associated OTU and other appurtenant equipment, including flasher unit and green conflict monitor, without crowding and so as to provide easy access for maintenance and test purposes. The Controller, associated equipment, and terminals shall be so arranged within the cabinet that they will not interfere with the entrance, training, and connection of incoming cables.

Details of the Controller cabinet design and equipment layout shall be submitted to the MOI/Engineer for approval.

1602.09.3 Physical Requirements

The Controller cabinet shall be weatherproof, rainproof and dust proof and shall be able to maintain the proper operation of equipment in the environment experienced in Kuwait. In particular, each Controller cabinet, except where the cabinet is to be located beneath a bridge and/or not subjected to direct sunlight, shall be fitted with a sun-shade. This sunshade shall be of a design approved by the MOI/Engineer and have a minimum clearance from ground level to the eaves of the sun-shade of 2 m.

The Sub-contractor may additionally elect to employ cooling fans to provide lower operating temperatures within the cabinet. In this case the flow of air or its cooling effect shall be monitored and, in the event of a failure, an external vandal resistant lamp mounted on the exterior of the cabinet shall illuminate. It shall be possible for the monitoring device to provide information for transmission to the central computer. Notwithstanding the use of such cooling devices, all equipment shall be designed to operate at temperature levels described in Clause 1601.01 of these Specifications.

The design of the cabinet shall be such that the door shall offer complete access to the interior of the housing and shall encompass substantially the full area of the front of the housing. It shall be secured by a device designed to prevent unauthorised entry to the housing and shall be provided with catches to hold the doors open at 90°, 180°, and 10°. For each cabinet type, the Sub-contractor shall provide, at no extra cost, a total of 24 keys or tools necessary to gain access to the interior of the housing.

Whilst each class of Controller, e.g. Intersection Signal Controller, Alternate Flashing Light Signal Controller, may be housed in cabinets of different design, all Controllers of the same class shall be housed in cabinets of identical design. Cabinets shall be base or post-mounted as appropriate.

1602.09.4 Electrical Terminations

a. Terminations shall be provided in the cabinets of signalised intersection Controllers for:
   i. Power cable.
   ii. Signal aspect cables – one terminal for each signal circuit and two or more for the common conductors.
   iii. Lead-in wiring from Detectors.
   iv. Pedestrian push button cables.

Additionally, space shall be provided for terminations for communication cables servicing the OTU.

b. Terminations shall be provided in the cabinets of Alternate Flashing Light Signal Controllers for:
   i. Power cable.
   ii. Signal aspect cables – one terminal for each signal circuit and two or more for the common conductors.
   iii. Push button cabling from remote stations and associated ‘confirmatory signal’ cabling.
   iv. Push button cabling from local stations, i.e. Emergency Detectors.

c. The terminals shall be mounted on a non-hygroscopic, non-inflammable base.

d. All terminals shall be suitably identified. The manner of marking and identification shall be subject to approval of the MOI/Engineer. The outgoing signal aspect circuits shall be of the same polarity as the line side of the power supply. The common return of the signal aspect circuits shall be of the same polarity as the neutral side of the power supply.

e. All cables shall be terminated in a convenient and readily accessible position without having to remove or move any equipment contained in the housing. The position of the terminals shall permit easy testing and maintenance. All terminals shall have separating barriers.

f. Power cable terminations shall comply with the Regulations of the Kuwait Ministry of Electricity and Water and with the relevant Clauses of the IEE, United Kingdom “Wiring Regulations for the Electrical Equipment of Buildings”. The current rating of cables shall comply with the appropriate tables of those Regulations for the class of conductor used.

g. Appropriate circuit breakers switch and radio interference filter shall be provided by the Sub-contractor for the connection of the Controller to the mains supply. A mains isolation switch shall also be provided.

1602.09.5 Electrical Protection

The various Controller components and their associated circuits shall be electrically protected at their housing terminals as follows:

a. Mains power terminals -- lightning arrestor, circuit breaker and appropriately rated varistor.

b. Detector terminals - appropriate transient protection.

1602.09.6 Grounding

Where a Controller is situated outdoors, the cabinet shall be securely connected to grounding electrodes and shall be equipped with a grounding busbar or a prominent terminal to which grounds of all equipment housed in the cabinet shall be connected. Where the Controller is situated indoors, e.g. within an Emergency Vehicle Station, the cabinet shall be connected to the grounding circuit of a suitable adjacent mains electricity supply. It shall be equipped with a grounding busbar or prominent terminal to which grounds of all equipment housed in the cabinet shall be connected.

1602.09.7 Power Sockets

Within all Controller cabinets two 13 ampere sockets shall be mounted, one for maintenance and test equipment and the other for power supply to the OTU. Each outlet shall be independently protected from electrical overloads through suitably rated circuit-breakers.

1602.09.8 Light Socket

A light socket with switch and 40 watt lamp shall be mounted in each cabinet of signalised intersection Controllers.

1602.09.9 Log Book

A logbook shall be provided at each cabinet to record maintenance inspections and current signal timings. The size and format of the logbook shall be subject to approval by the MOI/Engineer. The logbook shall be connected to the housing by a cord, two metres in length, or similar method so that it is difficult to remove. A pocket shall be provided within the cabinet for its storage.

1602.09.10 Police Facility

For Controllers at signalised intersections, the facility specified in Clause 1602.02.10 of these Specifications shall be provided. Access to this facility shall not entail opening the cabinet door referred to in Clause 1602.09.3 of these Specifications.

1602.09.11 Foundations

For Controllers at signalised intersections, the Sub-contractor shall design a suitable foundation for the cabinet, to be constructed in Class K300 concrete cast-in-situ and reinforced as required. Metal conduit shall be provided for the entry of power supply, signal lamp, and detector and push button cables and data transmission cables to the OTU. The cabinet shall be secured to the foundation by means of anchor bolts. The design shall be submitted to and approved by the MOI/Engineer.

Cabinets for Alternate Flashing Light Signal Controllers shall normally be mounted on pedestals as specified in Clause 1603.02.3 of these Specifications. The cabinet shall be securely fixed to a flange plate at the top of the pedestal. The design shall be submitted to and approved by the MOI/Engineer. Alternatively, where the Controller is contained within the same cabinet as the Emergency Detector(s) at Emergency Vehicle stations the cabinet may be wall mounted. The fixing details shall be approved by the MOI/Engineer.

1603 - SIGNAL HEADS AND SUPPORTS

1603.01 SIGNAL HEADS

1603.01.1 General

There shall be a confirmation from the traffic signal heads manufacturer confirming that the manufacturer warranty on signal heads is 5 years. A distributorship agreement between the Sub-contractor and the traffic signal heads manufacturer showing the validity dates of the relationship must be submitted to MOI/Engineer before ordering. The agreement must be registered with the Ministry of Interior Traffic Department.

1603.01.1.1 Applicable Standards

Signal heads shall comply with either:

a. NF EN 12368: Traffic Control Equipment Signal Heads, or
b. Institute of Transportation Engineers (ITE) Standard: Adjustable Face Vehicular Traffic Control Signal Heads, as amended. This standard does not apply to Alternate Flashing Light signals.

1603.01.2 Signal Aspects

All vehicular control signal aspects shall be 300 mm diameter. The design of the signal/lens assembly shall incorporate means of reducing phantom effects.

Lenses for vehicular traffic shall show a full circular aspect or an arrow indication oriented in an appropriate direction, all as shown on the Drawings. Pedestrian signal lenses shall depict a standing man on the red aspect and a walking man on the green aspect.

1603.01.2.1 Signal Aspects Optical Characteristics

The signal light emitted from the central optical source should be homogenous, and shall give a uniform optical signal. No visible DARK spots are allowed to appear in the event of failure of one or more diodes. LED's distributed in the inner surface of the lens are not acceptable.

Automatic light compensation in case of diode failure: In case of failure of one LED, the intensity of the light in the remaining LED's will increase to sustain the original light intensity of the Module. This shall be mentioned clearly on the datasheet of the module. A clear proof has to be submitted to theMOI/Engineer.

The LED should be High Flux providing a very high light output and supplied by a special designed constant current DC switch mode power supply with high efficiency. The light source shall constitute of no more than 6 nos. of High Flux LEDs combined at the center of the lens.

The Luminous intensity issued by the LEDs for the 300 mm diameter shall exceed 400 candelas, and shall exceed 200 candelas for the 210 mrn.

1603.01.2.2 Signal Aspects Electrical Characteristics

The electrical connections shall be of first quality bearing repetitive connections and dismantlement. The electrical wires shall be of first quality, flexible, and shall be specified for a temperature -40° C to 80° C.

The operating voltage of LED signal head should be 196 to 265 volts, 50 Hz.

Power consumption should be < 10W (Red 8w, Amber 8W, Green 9W).

The lifetime for the LED shall exceed 5 years operating with a temperature of 75 degrees centigrade. The operating temperature shall be -40° C to 75° C. The MOI/Engineer will reject any proposal that does not include the required information or if these information are considered inadequate by the MOI/Engineer.

1603.01.3 Signal Housings

Slim 3 aspect x 300 mm decorative design housing made of a combination of aluminurn and UVstabilized polycarbonate especially built for LED technology. Signal head must be impact resistant and vibration proof. The constructional integrity shall be suitable to meet the NF EN 60068-2-64 Test Fh, class AJ2 for random

vibration, and test NF EN 60598-1 :2004, 4.13.4 for impact. Housing color shall be black.

1603.01.4 Signal Mountings

Signals shall be mounted on pedestals, poles or overhead mast arms as stated in the Kuwait Manual on Uniform Traffic Control Devicesl. Mounting shall be provided for the easy and secure setting of the signal heads in the horizontal and vertical planes. It shall be possible to detach individual signal heads from their poles or masts.

Signals mounted singly on top of pedestal may be attached through the use of steel or cast aluminium bracket connected to the bottom at the signal head. All other signals must be mounted through the use of properly designed steel or cast aluminium brackets that attach to the top and bottom of the signal head. The Sub-contractor shall describe in detail the means of accomplishing this.

The attachment means used for attaching signal heads to mast arms or other overhead structures shall allow easy adjustment of signal head alignment. Adjustments shall be available to allow vertical height adjustment and two-plane rotational adjustment in a simple and straightforward manner using simple hand tools. The means of accomplishing this must be approved by the MOI/Engineer before installation. Full details and shop drawings shall be supplied by the Sub-contractor for approval. All attachments and wiring arrangement shall be submitted to the MOI/Engineer for approval.

1603.01.5 Backing Boards

A. Signalised Intersections

A backing board shall be provided with each vehicular signal face. It shall extend 300 mm above the centre of the upper optical system and 200 mm below the centre of the lower optical system. It shall extend 280 mm horizontally either side of the vertical centreline of the optical system unless there is an adjacent backing board associated with another signal face in which case the dimension may be reduced to 220 mm on the adjacent side. In the case of the three aspect vehicular display being accompanied by an additional arrow display or by a traffic sign integral with the signal head the backing board shall extend locally beyond the edge of the accompanying signal or sign by 130 mm. Backing boards shall not be provided with any pedestrian signal face.

Backing boards shall be finished in matt black and provided with a white border 45 mm wide on the front face. This border shall be of retro-reflective material.

Backing boards shall be constructed from a durable material and affixed securely to the signal head assembly.

B. Pedestrian Controlled Signalised Crossings

Backing board requirements shall be as those for signalised intersection installations.

C. Alternate Flashing Light Signal Installations

A backing board shall be provided for each Alternate Flashing Light signal erected on the public highway. It shall extend 300 mm above the centres of the red signal aspects and 300 mm below the centre of the yellow signal aspect. The overall width of the backing board shall be 1500 mm.

Backing boards shall be finished in matt black and provided with a white border 85 mm wide on the front face. This border shall be of retroflective material.

Backing boards shall be constructed from a durable material and affixed securely to the signal head assembly.

1603.01.6 Visors

Two types of sun visors shall be provided.

- Type-1, which is the standard shall have an opening angle of 132° and a length of 280 mm.
- Type-2 shall have an opening angle of 24° and a length of 550 mm.

1603.01.7 Signal Lights

Unless shown otherwise on the Drawings, all signal lights shall be LED. (See Clause 1603.01.2 of these Specifications).

1603.01.8 Signal Head Retrofit Module

The Modules to be supplied are of sizes 300mm for vehicles, and 210mm for pedestrian and shall be designed to replace the halogen optical assembly in existing Swarco-Futurit traffic signal heads; the modules shall conform to NF EN 12368 with optical and electrical characteristics as detailed below.

The modules shall be easily installed in the existing signal heads without any modifications. The LED board should be mounted into an aluminum cooling plate integrated into the plastic housing and heat losses should be directly transported out of the housing. Any new retrofit to be supplied must be compatible to the existing Standards Swarco-Futurit housing Such proof must be included with the submittal.

Environmental protection shall be IP 65 according to NF EN 60598-1.

Front lens cover to be tinted as per the aspect color (Red/Yellow/Green). Transparent lenses are not acceptable.

The design of the Module should ensure efficient removal of heat from the hermetically sealed casing.

Each LED Module shall have label which shows a unique serial number, a barcode or data matrix code that contains the manufacturing history of the Module, manufacturing date, supply voltage, color, diameter, power consumption rating, CE marking

1603.01.9 Integral Traffic Signs

Where shown on the Drawings, a traffic sign shall be incorporated into the signal head assembly. It shall be 300 mm diameter, and internally illuminated. The illumination shall be continuous and shall only be extinguished in the event of a power or internal lamp failure.

1603.01.10 Countdown Pedestrian Signals

1603.01.10.1 General

Each pedestrian signal shall be a complete operating unit with metal housing, cover glass, Z-crate visor, reflector and other parts, all in accordance with this Specification. The opening in the top and bottom of the housing shall be two inches in diameter. The top opening shall be smooth and shall provide a watertight seal. A screened ½-vent hole shall be located in the bottom of the housing. All exposed metal parts, except fastenings shall be primed and finished with a color approved by theMOI/Engineer.

LED Pedestrian Countdown Signal Face Module (Combination Raised Hand and Walking Person Section with Two Digit Countdown Timer). The module shall be designed as a retrofit replacement for the message-bearing surface of a pedestrian traffic signal housing.

Each module shall consist of an assembly that utilizes LEDs as the light source in lieu of an Incandescent lamp for use in traffic signal sections.

The LEDs shall utilize appropriate technology to achieve the required color and shall be the ultra bright type rated for 100,000 hours of continuous operation from -40ºC to +74ºC.

The modules shall be rated for a minimum useful life of 48 months. All modules shall meet all parameters of this Specification during this period. The individual LEDs shall be wired such that a catastrophic loss or the failure of one LED will result in the loss of not more than 5% of the signal module light output.

1603.01.10.2 Definition

The Sub-contractor shall furnish and install LED Countdown Pedestrian Signals using the international symbol, and the light source for the WALKING PERSON indication shall utilize white LEDs. The signal head shall conform to the Institute of Transportation Engineers' current ITE Standard for Pedestrian Signal Indications. The WALKING PERSON indication shall be Lunar White; the "UPRAISED HAND" indication shall be Portland Orange. Each pedestrian signal head shall utilize a Dialight Corporation LED module, Model 430-6473-001 or approved equal.

1603.01.10.3 Electrical

Maximum power consumption requirements for the area as follows (in Watts):

	25ºC	74ºC
"Hand"	10.0	12.0
"Walking Person"	9.0	12.0
Countdown Timer	10.0	12.0

The modules shall operate from a 50 Hz ±3 Hz AC line over a voltage ranging from 220 V to 260 V. The fluctuations of line voltage shall have no visible effect on the luminous intensity of the indications.

Operating voltage of the modules shall be 240 VAC. All parameters shall be measured at this voltage.

Power Factor – The LED signal module shall have a power factor of 0.90 or greater.

THD – Total harmonic distortion (current and voltage) induced into an AC power line by an LED signal module shall not exceed 20%.

Surge Suppression – The signal module on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients as stated in Section 2.1.6 of NEMA Standard TS-2, 1998.

The LED circuitry shall prevent perceptible flicker to the unaided eye over the voltage range specified above.

All wiring and terminal blocks shall meet the requirements of section 13.02 of the ITE Publication: Equipment and Material Standards, Chapter 2 (Vehicle Traffic Control Signal Heads).

Compatibility – The modules shall be operationally compatible with currently used Controller assemblies (solid state load switches, flashers, and conflict monitors).

When a current of 20 mA AC (or less) is applied to the unit, the voltage read across the two leads shall be 15 VAC or less.

The modules and associated on-board circuitry must meet Class A emission limits referred in Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.

1603.01.10.4 Environmental Requirements

The LED signal module shall be rated for use in the operating temperature range of -40ºC to +74ºC. The modules shall meet all specifications throughout this range.

The LED signal module shall be protected against dust and moisture intrusion per the requirements of NEMA Standard 250-2008 for Type 4 enclosures to protect all internal components.

1603.01.10.5 Construction

The LED signal module shall be a single-self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing. The power supply for the module shall be integral to the unit. The circuit board and power supply shall be contained inside the module.

The Assembly and manufacturing process for the LED signal assembly shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

Conductors shall be 1 m in length, with fully insulated female quick disconnect terminals attached to fit 6.35 mm tabs.

1603.01.10.6 Materials

Material used for the lens and signal module construction shall conform to ASTM specifications for the materials.

Enclosures containing either the power supply or electronic components of the signal module shall be made of UL 94 VO flame retardant materials. The lens of the signal module is excluded from this requirement.

1603.01.10.7 Module Identification

Each module shall have the manufacturer's name, trademark, model number, serial number, date of manufacture (month-year), and lot number as identification permanently marked on the back of the module.

The following operating characteristics shall be permanently marked on the back of the module: rated voltage and rated power in Watts and Volt-Ampere. If a specific mounting orientation is required, each module shall have prominent and permanent marking(s) for correct indexing and orientation within a signal housing. The markings shall consist of an up arrow, or the word "UP" or "TOP."

1603.01.10.8 Quality Assurance

The modules shall be manufactured in accordance with a manufacturer quality assurance (QA) Program. The QA program shall include two types of quality assurance: (1) design quality assurance and (2) production quality assurance. The production quality assurance shall include statistically controlled routine tests to ensure minimum performance levels of the modules built to meet this Specification, and a documented process of how problems are to be resolved.

QA process and test results documentation shall be kept on file for a minimum period of seven years.

LED signal module designs not satisfying design qualification testing and the production quality assurance testing performance requirements described below shall not be labeled, advertised, or sold as conforming to this Specification.

1603.01.10.9 Design Qualification Testing

Design Qualification Testing shall be performed by the manufacturer or an independent testing lab hired by the manufacturer of new LED module designs, and when a major design change has been implemented on an existing design.

A quantity of two units for each design shall be submitted for Design Qualification Testing. Test units and manufacturer's testing data shall be submitted to the MOI/Engineer after the manufacturer's testing is complete.

Burn In..- The sample module shall be energized for a minimum of 24 hours, at 100% on-time duty cycle, at a temperature of +74ºC before performing any design qualification testing.

Any failure of the module, which renders the unit non-compliant with the Specification after burn-in shall be cause for rejection.

For Design Qualifications Testing, all specifications will be measured including, but not limited to:

a. Rated Initial Luminous Intensity – Measured over the operating temperature range.
b. Chromaticity (Color) – Measured over the operating temperature range.
c. Electrical – All specified parameters shall be measured and used for quality comparison of production quality assurance on production modules. (rated power, etc.)
d. Equipment Compatibility – Modules shall be tested for compatibility with the Controller unit, conflict monitor, and load switch. Each signal module shall be connected to the output of a standard load switch connected to an AC voltage supply between the values of 220 and 260 VAC with the input to the load switch in the "off" position. The AC voltage developed across each LED signal module so connected shall not exceed 10 Vrms as the input voltage is varied from 220 Vrms to 260 Vrms.
e. Mechanical vibration testing shall be as per MIL-STD-883, Test Method 2007, using 3 four minute cycles along each x, y, and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens, of any internal components, or other physical damage shall be cause for rejection.
f. Temperature cycling shall be performed as per MIL-STD-883, test Method 1010. The temperature range shall be per "Environmental Requirements." A minimum of 20 cycles shall be performed with a 30 minute transfer time between temperature extremes and a 30 minute dwell time at each temperature. Module(s) being tested shall be energized and functioning throughout the duration of the test. Failure of a module to function properly or any evidence of cracking of the module lens or housing after temperature cycling shall be cause for rejection.
g. Moisture resistance testing shall be performed on all modules mounted in a standard type "A" pedestrian

housing per NEMA Standard 250-2008 for Type 4 enclosures. Any evidence of internal moisture after testing shall be cause for rejection.

1603.01.10.10 Production Quality Control Testing

The following Production Quality Assurance tests shall be performed on each new module prior to shipment. Failure to meet requirements of any of these tests shall be cause for rejection. Test results shall be retained by the manufacturer for seven years.

a. Burn-in period shall consist of each signal module being energized at rated voltage for a 30 minute stabilization period before the measurement is made.
b. Each module shall be tested for rated initial intensity after burn-in.
c. A single point measurement, with a correlation to the intensity requirements of section 1.04 of the VTCSH for circular modules, may be used.
d. The ambient temperature for this measurement shall be +25ºC.
e. Each module not meeting minimum luminous intensity requirements of 3,750 cd/m2 for Hand and 5,300 cd/m2 for Walking Person Symbol shall be cause for rejection.
f. Each module shall be tested for required power factor after burn-in.
g. Each module shall be measured for current flow in amperes after burn-in. The measured current values shall be compared against rated values resulting from design qualification measurements under "Design Qualification Testing." The current flow shall not exceed the rated value.
h. Each module shall be visually inspected for any exterior physical damage or assembly anomalies. Careful attention shall be paid to the surface of the lens to ensure there are no scratches (abrasions), cracks, chips, discoloration, or other defects. Any such defect shall be cause for rejection.

1603.01.10.11 MOI/Engineer Quality Assurance Testing (random sample testing)

The MOI/Engineer may perform random sample testing on all shipments.

Random sample testing should be completed within 30 days after delivery to the specified location on the purchase order.

All optical testing shall be performed with the module mounted in a standard traffic signal section or in a standard Type "A" Pedestrian Housing, but without a visor or hood attached to the section or housing.

The number of units tested (sample size) shall be determined by the quantity of each model in the shipment. The sample size shall conform to ANSI/ASQC Z1.4. The CALTRANS METS shall determine the sampling parameters to be used for the random sample testing.

All parameters of the Specification may be tested on the shipment sample.

Acceptance/Rejection of the shipment shall conform to ANSI/ASQC Z1.4 for random sampled shipments.

1603.01.10.12 Warranty

The Sub-contractor shall provide a written warranty against defects on materials and workmanship for the modules for a minimum period of 60 months after acceptance of the modules. Replacement modules shall be provided promptly after receipt of modules that have failed at no cost to the Employer/MOI. All warranty documentation shall be given to the Employer/MOI prior to random sample testing.

1603.02 SIGNAL SUPPORTS

1603.02.1 General

Signal heads shall, as indicated on the Drawings, be supported on:

A. <u>Pedestals</u>

where a single signal head is mounted directly on top of a vertical support, or

B. Poles

where one or more signal head is attached to a vertical support, or

C. Overhead Masts

where one or more signal head is attached to an outreach bracket (mast arm) cantilevered over the carriageway, and additionally one or more signal head may be attached to the vertical member supporting the mast arm, or

D. Gantries

where one or more signal head is mounted on a purpose built structure spanning the carriageway, or

E. Structures

where one or more signal head is mounted on an appropriate structure, such as an over bridge.

Means shall be provided for the easy and secure setting of the signal heads, including provision for adjustment in the horizontal and vertical planes. It shall be possible to detach individual signal heads from their supports.

The Sub-contractor shall design all supports to withstand the wind conditions of 135 km/h in Kuwait and shall submit such designs to the MOI/Engineer for approval.

1603.02.2 Attachment

Signals mounted singly on top of a pedestal may be attached through the use of an appropriate bracket connected to the bottom of the signal head. All other signals must be attached by rigid mounting brackets allowing easy adjustment of signal head alignment. Adjustments shall be available to allow vertical height adjustment and two-plane rotational adjustment in a simple and straight- forward manner using simple hand tools. The means of accomplishing this must be approved by the MOI/Engineer before installation. Full details and shop drawings shall be supplied by the Sub-contractor for approval.

Where a two-metre spread assembly is indicated on the Drawings, signals shall be attached both at the top and bottom through the use of the assembly to be specified by the Sub-contractor. The assembly shall allow the mounting of the required signal heads approximately two metres apart and shall provide for both vertical height and horizontal rotational adjustments.

1603.02.3 Pedestals and Poles

Pedestals shall be fabricated of 100 mm inside diameter standard weight steel tube conforming to ASTM A 53M Type E or Type S, Grade B.

Poles may be steel tube, as specified above, or tapered tube having a regular octagonal or circular cross-section. Tapered tube shall be fabricated of one full length of steel, conforming to ASTM A 1008M or an approved alternative, and continuously welded for the entire length by the submerged arc process. The exposed weld shall be ground or rolled smooth and flush with the base metal. The taper shall begin at the base and shall uniformly decrease at the rate commensurate with strength requirements. Caps shall be of the nipple or tenon type mounting fabricated or cast or malleable iron.

Unless otherwise permitted by the MOI/Engineer, shoe bases for pedestals and poles are to be fabricated from plate steel meeting the requirements of ASTM A 36M or cast steel meeting the requirements of ASTM A 27M, Grade 70-36. Details of the bases with the proposed anchor bolt size and length shall be submitted to the MOI/Engineer for approval prior to fabrication.

All anchor bolts, nuts and washers for the attachment of bases to the concrete footings shall be hot dipped galvanised in accordance with ASTM A-153M, or an approved alternative. The anchor bolts shall be completely galvanised and shall have a right angle bend and anchor plate at the end to be embedded in the concrete. The bolts shall be furnished in sizes and lengths as dictated by the structural requirements of the poles.

1603.02.4 Overhead Masts

Overhead masts are composed of two elements:

A. Uprights

The structural design of uprights shall be in accordance with the provisions of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, or approved alternative. For signal heads, a shape factor of 1.2 shall be used, and due account shall be taken of backing boards. The maximum deflection at the top of the upright under dead load conditions shall not exceed two percent of the height of the upright.

Uprights shall be of regular octagonal or circular cross section, of the tubular tapered type and fabricated of steel conforming to ASTM A-1011M Grade C or an approved equal. Shafts or sections shall be continuously welded for the entire length by the submerged arc process. The exposed welds shall be ground or rolled smooth and flush with the base metal.

The upright shall have no other longitudinal or circumferential welds except at the lower end joining the shaft to the base.

No field welding or any part of the upright will be permitted.

The taper, if present as a design feature for the upright, shall begin at base and shall uniformly decrease at a rate that is commensurate with the structural design requirements.

Access shall be provided to the interior of the upright by means of a flush type, reinforced handhole. This handhole shall be approximately 100 mm by 200 mm with a removable cover and shall be located at a point on the pole convenient to the base.

Unless otherwise permitted by the MOI/Engineer, anchor bases for uprights are to be fabricated from plate steel meeting the requirements of ASTM A36M or cast steel meeting the requirements of ASTM A27M Grade 70-36 or an approved equal. Cast steel or malleable iron bolt covers shall be provided and shall be attached to the base by means of stainless steel screws.

A grounding bolt or stud shall be provided on the inside of the upright immediately above the weld joining the shaft to the base and shall be readily accessible from the handhole.

B. Mast Arms

Mast arms shall be fabricated from steel pipes or other structural shape to lengths as specified on the Drawings. Their design shall conform to the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, or approved alternative. A shape factor of 1.2 shall be used, and due account shall be taken of backing boards. Maximum deflection at the tip of the mast arm shall not exceed 2% of its length under dead load conditions.

Mast arms shall be provided with rain-tight and dust-tight connections for attaching to the upright.

All hardware, except split pole clamps, shall be stainless steel. The end of the mast arm shall be suitably fabricated or fitted for easy access of wiring while remaining weather tight.

Steel pipe or other structural shape mast arms shall be standard weight black steel conforming to ASTM A 53M, Type E or Type S, Grade B, or an approved equal. All welding of steel shall conform to the AWS Structural Welding Code D1.1.72.

1603.02.5 Gantries

Where signals are to be mounted on gantries, the gantry design shall be as shown in the Drawings. All attachment arrangements shall be submitted to the MOI/Engineer for approval.

1603.02.6 Structures

Where indicated on the Drawings, signals shall be mounted on structures, new or existing. All attachment and wiring arrangements shall be submitted to the MOI/Engineer for approval.

1603.02.7 Shop Drawings

Prior to fabrication, the Sub-contractor shall submit to the MOI/Engineer for approval triplicate copies of detail shop drawings for each type of pole pedestal and overhead mast to be furnished under the Specifications. These drawings shall properly identify the overhead masts by length of outreach as specified on the Drawings. Each drawing shall also show the materials specifications for each component proposed for use. All welds shall be identified by types and sizes.

1603.02.8 Shop Painting

Each pole, pedestal, upright and mast arm shall be thoroughly cleaned and painted inside and out with one prime shop coat of zinc rich paint.

1603.02.9 Concrete Footings

The Sub-contractor shall design suitable footings for signal poles, pedestals and overhead masts. These shall be constructed in reinforced concrete, Class K300. The designs shall be submitted to and approved by the MOI/Engineer.

Two plastic raceways, 100 mm in diameter with bend radius of 600 mm shall be provided in each footing.

1603.02.10 Attachment to Footings

Unless otherwise permitted by the MOI/Engineer, shoe bases for poles, pedestals and uprights shall be as specified in Clauses 1603.02.3 and 1603.02.4 of these Specifications.

1603.02.11 Grounding

All metal poles, pedestals and overhead masts shall be grounded. Ground rods shall be installed when concrete for pole foundations is being poured so that they may be integrated within the pole base. Poles shall be equipped with an internal threaded stud so that an electrical connection may be made between the pole and ground rod. Alternative grounding methods may be used subject to approval of the MOI/Engineer.

1603.02.12 Sealing

All cable entrances into signal head hangers and signal poles pedestals and overhead masts shall be made with an insulated bushing and a drip loop.

1604 - DETECTORS

1604.01 PEDESTRIAN DETECTORS (PUSH BUTTONS)

1604.01.1 General

Where shown on the Drawings, push buttons shall be provided on the pedestals, poles or uprights as appropriate, to act as a device enabling pedestrians to insert a demand to the Controller for a particular phase, and the Controller to acknowledge receipt.

1604.01.2 Physical Requirements

Means shall be provided for securing the push button to the pedestal, pole or upright. Plungers and housings shall be designed so as to minimise the risk of jamming by foreign objects, moisture or the products of corrosion. They shall be weatherproof and designed to prevent the ingress of dust.

1604.01.3 Electrical Requirements

Contacts and connections shall be adequately insulated. No voltage in excess of 60 V (RMS) shall be connected to the push button terminals. The housings shall be grounded to the approval of the MOI/Engineer.

1604.01.4 Layout

The push button shall be conspicuous, and shall have associated with it a panel which is capable of being internally illuminated. When not lit, the panel shall appear blank, and when lit the word WAIT in Arabic and English language shall appear.

1604.02 EMERGENCY DETECTORS (PUSH BUTTONS) AT ALTERNATE FLASHING LIGHT SIGNAL INSTALLATIONS

1604.02.1 General

As shown on the Drawings, push buttons shall be provided at control centres remote from the signal Controller and/or on a panel on or adjacent to the Controller cabinet. They shall act as a device to insert a demand for the operational sequence of the alternate flashing light signals to commence.

1604.02.2 Physical Requirements

The positioning of demand buttons shall be as shown on the Drawings. The design of the plunger/button shall be appropriate to its positioning and shall be approved by the MOI/Engineer.

1604.02.3 Electrical Requirements

Contacts and connections shall be adequately insulated. No voltage in excess of 60 V (RMS) shall be connected to the push button terminals. Grounding arrangements shall be approved by the MOI/Engineer.

1604.02.4 Layout

Where the emergency detector is mounted on or adjacent to the Controller cabinet, the push button shall form part of the panel as described in Clause 1602.07.2 of these Specifications. Where mounted at a remote control centre the button shall be conspicuous and shall have the confirmatory signal indicator lamp mounted adjacent to it. Both shall be clearly marked.

1604.03 VEHICLE DETECTORS

1604.03.1 Solid State Loop Detector

1604.03.1.1 General

The purpose of this section is to specify the minimum acceptable requirements for the design and performance of a solid state loop detector. The detector shall detect the presence of vehicles above a loop of wire embedded in the pavement and connected to the detector electronic circuitry. The Sub-contractor shall be responsible for the design, manufacture, installation, and commissioning of the detector.

The loop detector comprising of the actual detector loop, the sensor unit and the power supply unit shall be fully suitable for service in the severe climatic conditions of Kuwait and the Sub-contractor shall guarantee that the equipment offered by him shall give prolonged and trouble free service at the road surface temperatures of over 80°C prevailing in Kuwait.

1604.03.1.2 Definitions

Each detector unit shall consist of one or more wire loop (loop) embedded in the roadway, and the loop amplifier (detector) housed in the Controller cabinet, and the feeders (lead-ins) between these items. These three components, operating together, allow the acquisition of traffic presence data.

1604.03.1.3 Radio Interference

The detector unit shall function correctly in the presence of radio interference at a level permitted by BS EN 55014 – Limits of Radio Interference.

1604.03.1.4 Mutual Interference

Adequate precautions shall be taken in the design of the equipment to prevent mutual interference between detector units when loops are located adjacent to one another. These precautions shall be at least sufficient to

avoid any interactions between detectors connected to a pair or loops, each loop being two metres square, which have their edges parallel to each other and spaced one meter apart.

1604.03.1.5 Power Supply

Power to the detector shall be supplied from the signal Controller.

1604.03.1.6 Surge Protection

The detector unit shall be adequately protected against electrical surges, lightning and transients which may be induced into the equipment, directly or by the sensing loop, loop feeder, or power supply. The detector unit shall not suffer damage if the loop is short-circuited or disconnected. Multiple-use protective devices shall be provided to the extent practical.

1604.03.1.7 Electrical Safety

Under no conditions shall the voltage, as measured across the loop and feeder terminal or between any terminal and earth, exceed 10 V peak to peak. This shall apply whether the sensing loop is connected or disconnected from the rest of the detector equipment.

If the power supply connected to the equipment is in excess of 60 V (RMS) the following safety requirements shall be met:

a. Power supply leads shall not be situated in the same multi-core cable as any other leads.
b. Suitable marking or labelling clearly indicating the presence of the power supply shall be provided on the outside of all covers, etc., which can, on removal, permit immediate access to the power supply terminals.
c. It shall not be possible to bridge accidentally any terminal or component carrying the power supply with any other terminal or component.
d. Non-current carrying metal parts of the equipment shall be bonded together and connected to an earthing terminal.

1604.03.2 Detector (Amplifier) Requirements

1604.03.2.1 Operation

Each detector shall have a single output which shall be actuated while a vehicle is either moving or stopped within the detection zone of the loop or loops connected to it. Presence data only is required on a phase basis. The detector shall be capable of operating from one to five loops simultaneously.

1604.03.2.2 Production Requirement

The detectors supplied shall be fully developed, standard production units.

1604.03.2.3 Sensitivity

The detector must have, as a minimum, the sensitivity to detect a 0.02% change of inductance at the amplifier loop terminals under the range of environmental conditions anticipated in Kuwait.

1604.03.2.4 Tuning Range

The detector supplied must be capable of being tuned to a loop plus lead-in inductance range of 50-700 microhenries at 50 kHz, impedance greater than 10,000 ohms and Q greater than five, where Q is the ratio of circuit reluctance to circuit resistance.

1604.03.2.5 Speed of Vehicles Detected

The detector when connected to a properly operating loop shall be capable of detecting vehicles travelling at any speed from 5 km/h to 160 kph.

1604.03.2.6 Classes of Vehicles Detected

The detector shall be capable of detecting all classes of motor vehicles when connected to a properly operating loop of 2 m by 2 m and 250 m of lead-in cable. The average error of the detector under such conditions as anticipated in Kuwait shall not exceed ±2%

1604.03.2.7 Detector Output

The detector output shall be through a circuit that is normally energised. The detection of a vehicle should de-energise this circuit and provide a relay operation. Both normally closed and normally open contact terminals shall be made available for use.

1604.03.2.8 Power Interruption

In the event of a power interruption to the detector, the output circuitry shall indicate a continuous presence. Following the restoration of power, the detector must retune and resume normal operations in less than 10 seconds.

1604.03.2.9 Tuning Controls

Detectors shall be self-tuning over the required tuning range. Detectors that have sensitivity controls shall have these controls located conveniently and any special tools or test sets that are necessary shall be provided at no extra cost. Detectors that are tuned at the factory should be furnished along with any devices that are necessary for such tuning other than standard electronic test equipment.

1604.03.2.10 Drift Compensation

The detectors shall incorporate adequate automatic compensation against the effects of any changes in environmental conditions. Upon installation, the detector shall commence operating properly without the need for manual adjustment as long as the loop to which it is attached is in proper operating condition.

1604.03.2.11 Continuous Presence

The detector shall produce a constant output so long as a vehicle occupies the space over the detector loop. A means shall be provided for the user to select a time, in the range 1 to 25 minutes, after which the detector shall be capable of detecting vehicles, which subsequently pass over the loop.

1604.03.2.12 Housing

Detector shall be located in the Controller cabinet, with the Controller to which the detector output is connected.

The housing of the detector station shall be constructed of anodized aluminum. The minimum thickness of the sheets shall be 3 mm.

The housing shall be of sufficient size to accommodate the control module or unit, the detectors, modem, power supply and all necessary accessories such as terminals and breakers etc. The housing shall be waterproof and dust proof.

The door of the housing shall provide complete access to the interior of the housing. Any keys or special tools required for opening the housing shall be provided at no additional cost. All housings shall be identical in design and base mounted.

1604.03.2.13 Physical Characteristics

The physical characteristics of the detectors may take one of two forms. Detectors may be fully self-contained, individual units encased separately, or they may be rack-mounted, printed circuit boards mounted with appropriate connectors.

A. <u>Self contained</u>

The detector shall utilise only solid state components throughout with the exception of an electro-mechanical relay used as an output device. The relay life expectancy shall be greater than 1×10^9 operations at rated load. The output relay shall have contacts rated at 300 milli-ampers at 32 V DC. The relay shall be a plug-in type unit and shall have a dust cover. All printed circuit boards shall be glass epoxy and shall have a minimum of 60

gram copper foil. Alternatively, a solid state output may be provided conditioned upon these same requirements in terms of life expectancy and load ratings.

The detector shall be encased in a dustproof cover, which shall be made of aluminium and painted.

Electrical connections of both the incoming and outgoing circuits shall be made by means of a screw-secured plug. The detector shall be replaceable with a similar unit without the necessity of disconnecting and reconnecting individual wires leading there from. The plug shall be of recessed male construction and rigidly fixed to the front of the detector unit. The mating plug receptacle shall be attached to one end of a connecting cable two metres long that has tagged leads. Each of these shall be fitted with a spade-type plug for easy attachment to the Controller terminal blocks.

B. Rack-Mount

Under this format, each detector must meet the same operating requirements as specified for self-contained detectors.

Rack-mount detectors should have a power supply, suitably fused, that has adequate capacity to provide power for all the detector positions which exist in the rack, whether the positions are utilised or not.

Electrical connections for rack-mount detectors of both incoming and outgoing circuits shall be made by means of a suitable card-edge connector. The detector shall be fully contained on a single circuit board and shall not require the use of special tools for either insertion or removal from its rack-mounting position. Positive locks shall be provided to hold the detector securely in its intended rack position. Only simple hand tools, such as a screw driver, shall be required to operate the locking device.

1604.03.2.14 Terminations

Terminations shall be provided in the detector casing for power cables and loop feeder cables. The relevant requirements of Clause 1602.09.4 of these Specifications shall apply.

1604.03.3 Loop and Lead-In Requirements

The types of wire to be used for the roadway loop and the lead in shall conform to the specifications and requirements of the detector manufacturer. All roadway loops and lead-ins shall be continuous lengths of wire with no splices. Loop wires shall be routed to a handhole behind the curb as directly as possible in all cases. A connection shall be made between the loop wire and the lead-in wire in this handhole. The lead-in wire shall be a shielded, twisted pair cable having load dielectric constant insulation. The loop and lead-in conductors shall be insulated and shall meet IMSA Specification 19.1 – 19.6 and 20.1 – 20.6 or approved alternative. The insulation shall be waterproof and shall withstand a temperature of 105°C without suffering damage or deformation.

Bending the loop and lead-in conductors through a 90-degree bend of 25 mm minimum inside radius shall not damage the conductor or its insulation. The insulation resistance of the loop and lead-in to earth shall have a measured resistance of not less than ten megohms when tested with a voltage of 500 V DC following final installation.

1604.03.4 Detector Station

The Sub-contractor shall supply and install detector stations which shall collect, store and transmit traffic data to the existing management system QuicNet/4 at M.O.I traffic department via 4 wire telephone lines. The collected data shall include traffic volume, occupancy and average speed of passing vehicles. The Sub-contractor shall provide evidence of full compatibility of the detector stations with existing management system.

The detector station shall consist of an aluminum housing as stated in Clause 1604.03.2.12 of these Specifications, control module or unit, power supply a modem (as specified in Clause 1602.05.29 of these Specifications) and 14 Nos. of 2 Channel detectors.

1604.03.5 Wireless Magnetometer Vehicle Detector

1604.03.5.1 General

Each component shall be UL listed. The date of manufacture for each component, as shown by date codes or serial numbers of electronic circuit assemblies, shall not be more than six months from the date of the

installation. Each component, except modem, shall carry a 2-year unconditional warranty, unless a longer duration is specified below.

1604.03.5.2 Definition

A detector capable of being actuated by the magnetic disturbance caused by the passage or presence of a vehicle.

1604.03.5.3 Components

Each wireless magnetometer vehicle detector station (WMVDS) shall consist of:

1. Pole(s)
2. One or more Vehicle Sensor Node(s) (VSN)
3. Repeater(s) (RP), as needed
4. One Access Point (AP);
5. Two PhotoVoltaic (PV) panels with panel support structure
6. One PV controller
7. Two batteries
8. One modem
9. One antenna
10. One Power Over Ethernet injector
11. One Ethernet hub
12. One enclosure
13. Sealants
14. Category 5E cables
15. Pull boxes, grounding electrode, conductors, conduits, pull rope
16. Miscellaneous wiring and devices as shown on the Drawings and in conformance with these Specifications.

1604.03.5.4 Availability of Components

Arrangements should be made to ensure that the Sub-contractor can obtain these components and related materials directly from the manufacturer.

1604.03.5.5 Vehicle Sensor Nodes

Each vehicle sensor nodes (VSN) shall consist of a magnetometer sensor, a microprocessor with firmware in non-volatile memory, a wireless transceiver and a battery within a single housing.

The magnetometer sensor shall detect the presence of a vehicle by a change in the vertical component of the earth's magnetic field within the detection zone corresponding to a 1.8 m by 1.8 m Type A inductive loop, with the VSN at the center. Each VSN shall continuously report the presence of the vehicle until the vehicle leaves the detection zone, whereupon the VSN shall report the absence of presence within 5 +/- 1 millisecond.

The housing shall be fully encapsulated to provide a minimum of 8 years of operation, over a temperature range of -30°C to 70°C.

Each VSN shall be individually addressable with a unique identifier, and capable of transmitting its data to the AP directly or via a RP. Each VSN shall also be capable of receiving detector parameters, microprocessor firmware and other commands from the AP directly or via a RP without loss of data.

1604.03.5.6 Sealant

The sealant for the installation of each VSN shall be a two-component, 100% solids, polyurea-based joint sealant and approved by the manufacturer of the VSN. It shall be a self-leveling joint sealant and shall be applied at a minimum temperature of 0 °C.

Physical Properties:

Tensile Strength (PSI)	ASTM D412	2950
Elongation (%)	ASTM D412	350
Hardness (Shore A)	ASTM D2240	95A
Flexibility 1/8" Mandrel	ASTM D1737	Pass
Taber Abrasion (mg loss) CS18 Wheel 1 kg per 1000 cycles	ASTM D4060	25
Gel Time	Minutes	2
Tack Free Time	Minutes	5
Open to Traffic	Minutes	15

1604.03.5.7 Repeaters

Each repeater (RP) and its battery shall be housed in a NEMA type 4 enclosure. The enclosure with RP and battery shall be 127 mm tall by 152 mm wide by 63.5 mm deep, with a maximum weight of 2.3 kg.

Each RP shall operate continuously over a temperature range of -37°C to 74°C.

The battery shall have a minimum life of 8 years and shall be field-replaceable with the use of common hand tools only.

Each RP shall be capable of communicating with and retransmitting data from a minimum of 16 VSN, using an FCC-approved communications link.

1604.03.5.8 Access Points

Each access point (AP) shall be housed in a NEMA type 4 enclosure. The enclosure with AP shall be 127 mm tall by 152 mm wide by 63.5 mm deep, with a maximum weight of 2.3 kg. Each AP shall operate continuously over a temperature range of -30°C to 70°C.

Each AP shall operate using Power over Ethernet, at a maximum of 1.5 W. Each AP shall be capable of communicating with and collecting data from a minimum of 64 VSN, either directly or via one or more RP, using an FCC-approved communications link. Each AP shall be able to communicate to an RP that is a minimum of 229 m away when both units are installed 5.5 m above the roadway.

1604.03.5.9 Ethernet Interface

Each AP shall have a 10/100-BaseT Ethernet communication port, which shall support Internet Protocol (IP) addressing via either Dynamic Host Configuration Protocol (DHCP) or static IP. Each AP shall have an RJ-45 connector mounted on the bottom of its housing. Each AP shall be addressable and shall transmit traffic data when polled by the Data Concentrator.

1604.03.5.10 Transmission Control Protocol/Internet Protocol Support

Each AP shall support the following protocols: Telnet, ftp, http, ppp, and pptp.

1604.03.5.11 Traffic Data

The AP shall provide the following traffic data per lane:

1. Vehicle count in a data collection interval, in units of vehicles
2. Lane Occupancy in a data collection interval, in units of 0.05%
3. Vehicle speed per vehicle, in units of kilometers per hour (kph)
4. Median vehicle speed in a data collection interval, in units of kph
5. Mean vehicle speeds in a data collection interval, in units of kph
6. Distribution of vehicle speeds in a data collection interval; in bins of < 50 kph, 50-54 kph 55-59 kph, 95-99 kph, and >= 100 kph; in units of vehicles
7. Vehicle length per vehicle, in units of 0.03 m

8. Distribution of vehicle lengths in a data collection interval; in bins of < 6 m, 6-12 m, 12-18 m, and >= 18 m; in units of vehicles

Each traffic data parameter shall be individually user-selectable. The length of a data collection interval shall be user-selectable from a list containing at minimum, the following values: 30 seconds, 1 minute, 5 minutes, 15 minutes, 1 hour and 24 hours.

1604.03.5.12 Photovoltaic

Each PV Panel shall be designed to operate over a temperature range of -10°C to 65°C.

Each PV Panel shall contain either single- or multi-crystal technology. The front surface of each panel shall be textured and coated with an anti-reflective film. Each panel shall be provided with multiple redundant contacts and shall be electrically matched for increased efficiency. Each panel shall provide electrical grounding of all metal surfaces.

Each PV Panel shall have a minimum rated power output of 80 W, +/- 5%, with a minimum short-circuit current rating of 4.8 A and a minimum open-circuit voltage rating of 21.7 V. These ratings shall be based on test conditions of 1000 W/square meter, cell temperature of 25°C, and air mass of 1.5, per ASTM E1036M.

Each PV Panel shall resist damage from the impact of 25 mm diameter hailstones traveling at 80 kph.

Each PV Panel shall have maximum dimensions of 1.2 m long by 0.7 m wide, with a maximum area of 0.74 sq meters, by 51 mm, with a maximum weight of 10.4 kg.

Each PV Panel shall pass salt tests to MIL-STD-810. Each PV Panel shall carry a minimum 20-year power warranty.

Each PV Panel shall have a rugged aluminum vented backing riveted to an aluminum panel equipped with welded aluminum brackets for attachment to the bracket arm. Stainless steel hardware shall be used for mounting the PV Panel to its panel support structure.

1604.03.5.13 Panel Support Structure

The Panel Support Structure shall hold 2 PV Panels, mounted side-by-side, on the type of pole and at the angle shown on the Drawing, to withstand winds of 137 kph.

1604.03.5.14 Batteries

Each battery shall be identical in make and model. All connections shall be marine-grade. Each battery shall be 100% recyclable and capable of a minimum of 1000 cycles to 25% depth of discharge (DOD) and 300 cycles at 50% DOD at a 20-hour rate.

Each battery shall be maintenance-free, sealed prismatic lead-calcium based, absorbed glass mat/valve regulated lead acid (AGM/VRLA), deep-cycle, heavy-duty type. Each battery shall:

1. have a voltage rating of 12 VDC,
2. be group size 27 (or 330 mm x 178 mm x 254 mm),
3. have a 100 A-h rating at a 100-hour discharge rate,
4. have a carrying handle,
5. be marked with date code and maximum recharge data and recharge cycles,
6. have 2 top mounted terminal posts with hardware that will accept a ¼-inch diameter bolt,
7. be fully charged when furnished,
8. be free from damage or deformities,
9. have a maximum weight of 32 kg, and
10. be certified by the manufacturer to operate over a temperature range of -25°C to 74°C.

1604.03.5.15 PV Controller

Each PV Controller shall be designed to provide 12 VDC, 24 hours per day. Each PV Controller shall be designed to charge AGM/VRLA heavy-duty batteries. Each PV Controller shall be designed to operate over a

temperature range of -10°C to 50°C. Each PV Controller shall regulate the voltage and current coming from the PV panels going to the batteries and to the load. Each PV Controller shall prevent overcharge and over-discharge of the batteries beyond the levels recommended by the battery manufacturer. Each PV Controller shall use series regulation.

Each PV Controller shall have maximum dimensions of 203 mm wide by 102 mm deep by 51 mm, with a maximum weight of 0.9 kg.

Each PV Controller shall have terminals that will accept #12 AWG wire.

Each PV Controller shall meet the following requirements:

Parameter	Minimum Requirements
Rated PV Current	15 A
Rated Load Current	15 A
System Voltage	12 VDC
Operational Current	35 mA
Digital Meter	Displays Battery Voltage, PV Current and Load Current
Connections	Screw terminals for PV Panels, Battery and Load
LED Indicators	Charging, Battery Status and Temperature Sensor
Load Disconnect Switch	Can disconnect the Load or both the Load and PV Panels
Self-test	Tests all Load/Charge Controller internal circuits.

1604.03.5.16 Modem Components and Configuration

The General Packet Radio Service (GPRS) Modem shall be configured with the following major components:

1. Modem
2. Modem mounting bracket and hardware

The mounting bracket and hardware shall be stainless steel. The mounting bracket shall securely hold the modem in a vertical position with all cables and conductors installed. The mounting bracket shall contain the modem using a method that allows the removal of the modem without tools or without removing the bracket from its attachment to the enclosure.

Each modem shall be configurable remotely through the wireless network and through the modem ethernet port. Each modem shall be complete with all cables, conductors, hardware and other equipment as required to make the system completely operational. Location and mounting of the equipment shall be directed by the MOI/Engineer and details shown on the Drawings. Each modem shall be fully-compliant with PCCA STD-101.

1604.03.5.17 Modem Environmental Requirements

The operating temperature range of the modem shall range from -30°C to +70°C, with humidity from % to 95% (non-condensing) and have transmissions at 10% duty cycle above 60°C.

1604.03.5.18 Modem Physical Characteristics

Each modem shall weigh less than 0.9 kg and have maximum dimensions of 178 mm × 102 mm × 32 mm. The housing shall be constructed of anodized aluminum.

Each modem shall have the following status indicators mounted on its front panel:

1. Power (on).
2. Channel Acquired.
3. Link Status.
4. Network Registration.
5. Received Signal Strength Indicator.
6. Transmit and Receive Data.
7. Block Errors.

Each modem shall have the following connectors mounted on its rear panel:

1. One RJ-45 socket connector.
2. One 50 Ω TNS socket connector.
3. One DC power connector.

1604.03.5.19 Modem Operational Parameters

Each modem shall be able to operate in a dynamic IP addressing environment of GPRS Networks at 1900/850 MHz.

Transmit frequency	1850-1910 MHz and 824-849 MHz
Transmit power at antenna port	1.0 W for 1900 MHz and 0.8 W for 850 MHz
Receiver frequency	1930-1990 MHz and 869-894 MHz
Receiver sensitivity	-107 dBm (2.439 % bit error rate)
Input voltage	10 VDC to 28 VDC
Input current	40 mA to 200 mA

1604.03.5.20 Modem Application Interfaces

The modem shall have the following standard interfaces:

1. The AT command serial character stream uses TCP/IP.
2. Host communicates with modem using either UDP or TCP packet modes.
3. Computer terminal platform using a Windows Operating System recommended by the WMVDS manufacturer and Dial-Up Networking communicates with the modem using PPP.

1604.03.5.21 Modem Features

Each modem shall have the following features:

1. 53.6 kbps raw data transfer rate minimum.
2. Full duplex transceiver.
3. 1900/850 MHz dual-band networking.
4. Integrated TCP/IP protocol stack with UDP.
5. Security to prevent unauthorized access.
6. DC power cable at least 1 m in length with a mating connector for the modem power connector.
7. Packet buffering and forwarding feature that provides discipline to the output of the Ethernet port. The packet forwarding time interval shall be configurable from a rate of 0 ms (undisciplined) to 400 ms in increments of 100 ms or less.
8. Choice of "Friends Only" access mode.

1604.03.5.22 Modem System Compliance

The modem and associated firmware, software, hardware, protocol, and other features shall be fully and completely compatible with the existing GPRS network currently in use. The Sub-contractor shall demonstrate the compatibility to the MOI/Engineer by actual installation demonstration or by other means approved by the MOI/Engineer.

1604.03.5.23 Modem Installation

The installation of the modem shall be according to the Drawings, the manufacturer’s instructions, and adjusted per field conditions with the MOI/Engineers approval.

1604.03.5.24 Modem Initialization and Configuration

The Sub-contractor shall deliver each modem and wireless modem harness to the MOI/Engineer 30 working days before installation. The MOI/Engineer will return the programmed modem with the corresponding project

location number, PDP context, APN, and harness within 15 working days. The Sub-contractor will record the serial number of the modem on the check list sheet.

1604.03.5.25 Modem Certificate of Compliance

The Sub-contractor shall provide the MOI/Engineer with a Certificate of Compliance from the manufacturer. The certificate shall be signed by the manufacturer of the material or the manufacturer of assembled materials and shall state that the materials involved comply in all respects with the requirements of the Specifications. A Certificate of Compliance shall be furnished with each lot of material delivered to the work and the lot so certified shall be clearly identified in the certificate.

Materials used on the basis of a Certificate of Compliance may be sampled and tested at any time. The fact that material is used on the basis of a Certificate of Compliance shall not relieve the Sub-contractor of responsibility for incorporating material in the work which conforms to the requirements of the Drawings and Specifications, and any material not conforming to the requirements will be subject to rejection whether in place or not.

The MOI/Engineer reserves the right to refuse to permit the use of material on the basis of a Certificate of Compliance.

The form of the Certificate of Compliance and its disposition shall be as directed by the MOI/Engineer.

1604.03.5.26 Modem Warranty

The Sub-contractor shall provide a written warranty against defects in materials and workmanship for modems for a period of 12 months after installation for parts and labor. Replacement modems shall be provided within 5 days after receipt of failed modem at no cost to the Employer/MOI. All warranty documentation shall be given to the MOI/Engineer prior to installation. Replacement modems shall be delivered to the Ministry of Interior.

The software warranty shall be for one (1) year, including upgrades and feature enhancements.

1604.03.5.27 Modem Antenna

The antenna shall be the low-profile disk-type, and shall adhere to the enclosure using a factory-installed double-sided waterproof acrylic foam adhesive. The coax cable shall be at least 1 m in length and shall have a 50-Ω TNC connector on the modem end. In addition, the antenna shall meet the following requirements:

VSWR (at resonant point)	2:1 or less
Frequencies	1850-1990 MHz and 824-894 MHz
Nominal Impedance	50 Ω
Gain	2 dB
Radiation Pattern	Omni-directional
Polarization	Vertical

The antenna shall contain a reflective ground plane which shall extend beyond the antenna at least 200 mm in all directions.

1604.03.5.28 Ethernet Hub

Each Ethernet Hub shall operate on 12 VDC and 5 W maximum.

Each Ethernet Hub shall be a 4-port device. Each port shall have an RJ-45 socket connector. Each Ethernet Hub shall have a metal case suitable for outdoor applications and shall be designed to operate over a temperature range of -10°C to 50°C.

1604.03.5.29 Enclosure

The enclosure shall be NEMA Type 4 with dimensions as shown on theDrawings. The enclosure shall have two separate and sealed compartments; the top compartment for equipment installation, and the bottom one for battery storage. Each compartment shall have a padlockable door. The enclosure shall have 12 mm ACX plywood mounted on the inside back wall of the upper compartment to enable mounting of equipment.

1604.03.5.30 Power Over Ethernet (PoE) Injector

Each Power over Ethernet Injector shall be compliant with IEEE 802.3af-2003. Each Power over Ethernet Injector shall have two RJ-45 socket connectors, one powered and one unpowered. Each Power over Ethernet Injector shall provide three-stage surge protection for the AP. The first stage shall be comprised of a differential gas discharge tube. Stage two shall be a pair of current limiting series resistors. The final stage shall be a high-speed, low-capacitance diode clamp array. Grounding lugs and terminals shall be provided directly on the data surge protector housing to earth ground. A minimum of No. 10 gauge copper wire shall be used. A braided cable made specifically for grounding purposes may also be used.

The data surge protection shall meet the following requirements:

1. Radio Frequency (RF) Power: 30 W minimum;
2. Data Clamping Voltage: 15 V on pins 1, 2, 3 and 6;
3. Power Clamping Voltage, when used: 58 V on pins 4, 5, 7 and 8;
4. Energy Rating: 400 J minimum;
5. Response time: 1 nanosecond maximum.

Each Power over Ethernet Injector shall have a case suitable for outdoor applications.

1604.03.5.31 Cables

DC wires; Category 5E cables from AP to hub and radio to hub. Outdoor rated Category 5E shielded twisted-pair (STP) and unshielded twisted-pair (UTP) cables shall meet requirements as specified in the TIA/EIA-568B standards. Category 5E UTP Cable shall be 1 m long and terminated with RJ-45 connectors.

1604.03.5.32 Submittals

Each submittal shall be delivered to the MOI/Engineer at least 15 working days prior to installation at the project Sites. The MOI/Engineer shall be allowed 5 working days for the review of the submittal. The submittal shall include cutsheets for all proposed electrical components required.

The Sub-contractor shall submit the battery data sheet to the MOI/Engineer when the batteries are delivered to the jobsite. The data sheet shall include the following features:

a. Model number,
b. Serial number,
c. Dimensions,
d. Table of discharge rating,
e. Product information,
f. Battery specifications, and
g. Conductivity reading per battery (in Siemens).

The Sub-contractor shall submit a materials list to the MOI/Engineer. Installation and materials shall conform to the requirements of the manufacturer and these special provisions. All equipment, cables and hardware shall be part of an engineered system that is specifically designed by the manufacturer to fully inter-operate with all other system components. Mounting assemblies shall be corrosive-resistant. Connectors installed outside the cabinets and enclosures shall be corrosive-resistant, weather-proof and watertight. Exposed cables shall be sunlight-and weather-resistant. Cables shall be labeled with permanent labels at each end.

1604.03.5.33 Acceptance Testing

The Sub-contractor shall notify the MOI/Engineer 15 working days before the WMVDS is ready for acceptance testing. Acceptance testing shall be scheduled to be conducted in the presence of the MOI/Engineer during a normal work day (Sunday to Thursday 0800 to 1600). The Sub-contractor shall demonstrate the operation of each WMVDS satisfying the functional requirements of these special provisions. The MOI/Engineer has the right to reject the WMVDS if the demonstration fails.

All necessary software and equipment, including documentation, needed for the acceptance testing of each WMVDS shall be provided by the Sub-contractor. All software shall operate on a laptop computer running a Windows Operating System recommended by the WMVDS manufacturer.

The MOI/Engineer will review the results from the acceptance testing and accept or reject the results within 7 days. Determination of any vehicle anomalies or unusual occurrences will be decided by the MOI/Engineer. Data or counts that are not agreed upon by the MOI/Engineer shall be considered errors and count against the unit's calibration. If the MOI/Engineer determines that the WMVDS does not meet the performance requirements, the Sub-contractor will have seven days to re-calibrate and re-test the unit and re-submit new test data. Following three failed attempts, the Sub-contractor shall replace the WMVDS component(s) with new component(s).

Repair, replacement, and retesting of WMVDS components due to failure or rejection shall be at the Sub-contractor's expense.

1604.03.5.34 Warranty

The Sub-contractor shall provide a written unconditional warranty against defects in material and workmanship for the WMVDS, for a period of 24 months after acceptance (except modem). After final acceptance of the WMVDS, all replacement assemblies covered under warranty shall be provided within 10 days after receipt of failed units at no cost to the Employer/MOI. All warranty documentation shall be given to the MOI/Engineer prior to installation. All replacement WMVDS components shall be delivered to the Ministry of Interior.

Standard updates to the VSN, RP and AP software which are available from the manufacturer shall be delivered by the Sub-contractor without charge to the Employer/MOI during the warranty period.

1604.03.5.35 Training

The Sub-contractor shall provide a minimum of 6 hours of training by a certified manufacturer's representative for up to 6 persons selected by the MOI/Engineer. The content of the training shall include instruction on how to align, program, adjust, calibrate and maintain the WMVDS. The Sub-contractor shall provide materials and equipment for the training. The Sub-contractor shall give the MOI/Engineer 15 days notice prior to the training. The time and location of the training shall be agreed upon by the MOI/Engineer and the Sub-contractor. If no agreement can be reached, the MOI/Engineer shall determine the time and location.

1604.03.6 Magnetic Detector

1604.03.6.1 Definition

A detector capable of being actuated by the induced voltage caused by the passage of a vehicle through the earth's magnetic field.

1604.03.6.2 General

The term "magnetic detector" applies to a complete installation consisting of a sensing element or group of sensing elements installed in the roadway as shown on the Drawings, lead-in cable and an amplifier with integral power supply installed in a Controller cabinet.

Each magnetic detector amplifier shall be a low noise, high gain amplifier designed for use with all types of magnetic detector sensing units commonly implemented in transportation projects.

Sensitivity of units shall be readily adjustable by a knob on the front panel.

An indicator light shall be provided to indicate detector operation.

The sensing elements shall be no larger than 57.15 mm in diameter and shall contain no moving parts or transistors. The element casing shall be constructed of non-ferrous materials suitable for use in the environment in which it will operate, and shall be sealed to prevent the entrance of moisture. The element shall be shaped to facilitate pushing into conduit and shall not have any sharp edges along its length. The overall length of the sensing element shall not exceed 0.53 m.

Magnetic detector sensing elements and amplifiers to be installed at any one intersection or any one traffic count station shall be of the same make and type.

1604.03.6.3 Performance Characteristics

Each magnetic detector shall be capable of being activated by a voltage induced in the coil of the sensing element by the passage of a vehicle at any speed from 5 km/h to 130 km/h.

Any vehicle passing within 1.8 m of either end of the sensing element shall provide an output closure.

1604.03.6.4 Amplifier Unit Construction

Each amplifier shall be provided with an integral power supply. Each amplifier shall be designed to provide ease of maintenance with all electronic components readily accessible. All input and output circuits for each amplifier shall enter via a single MS connector, circuitry for which shall be as shown in the following table:

Connector Circuitry For Magnetic Detector Amplifiers

MS Connector Circuit	18-8 Pin
Magnetic Detector (-)	A
Magnetic Detector (+)	B
240 V, (ac+)	C
Chassis Ground	D
Detector Common	E
Output N.O.	F
Output N.C.	G
240 V, (ac-)	H

All controls, indicator lights, fuseholders, and connectors shall be mounted on the front panel of the amplifier.

1604.03.6.5 Construction Materials

The cable from the pull box adjacent to the magnetic detector sensing element to the field terminals in the Controller cabinet shall be the type specified for inductive loop detectors.

1604.03.6.6 Sensing Element

Each sensing element shall be designed for ease of installation, repositioning, and removal.

The sensing element shall be 56.9 mm maximum in diameter, have no sharp edges, and its length not to exceed 0.48 m. The sensing element shall be constructed of nonferrous material and shall be moisture proof. The sensing element shall contain no moving parts or active components.

The sensing element shall have a 30 m lead-in cable.

Leakage resistance shall be a minimum of 10 MegaOhms when tested with 400 VDC between lead wire, including lead wire entrance, and the fluid of a salt water bath after the device has been entirely immersed in the bath for a period of 24 hours at 20°C +/-20.8°C. The salt water bath concentrate shall be 7.1 g of salt per 3.785 liters of water.

1604.03.6.7 Lead-In

Each sensing element including lead-in shall have a DC resistance of less than 3500 Ohms and an inductance of 20 Henrys +/- 15%.

1604.03.6.8 Two Channel Magnetic Detector Sensing Unit

When resident in an active cabinet input assembly and attached to one or more Sensing Elements resident in conduit under the travel way, the sensing channel shall output a Ground True Output to the Controller Unit when sensing an induced voltage caused by a Typical Motorized Vehicle passing within 1.8 m from an element with a 305 m of lead-in cable at all speeds between 5 km/h and 130 km/h. The sensing channel output shall be continuous as long as the vehicle is detected.

A rotary sensitivity adjusting knob for Gain (0 to Full) and a momentary test switch providing a voltage test input shall be furnished for each channel on the front panel.

1604.03.7 Video Detection

1604.03.7.1 General

This Clause sets forth the minimum requirements for a system that detects vehicles on a roadway using only video images of vehicle traffic.

The video detection system shall consist of one or two video cameras, a video detection processor (VDP) which mounts in a standard detector rack; a detector rack mounted extension module (EM), surge suppressor for video, and a pointing device.

The system shall include software that detects vehicles in multiple lanes using only the video image. Detection zones shall be defined using only an on board video menu and a pointing device to place the zones on a video image. Up to 24 detection zones per camera shall be available. A separate computer shall not be required to program the detection zones.

1604.03.7.2 Functional Capabilities

The VDP shall process video from two sources. The source can be a video camera or video tape player. The video shall be input to the VDP in NTSC (North America, National Television System Committee) or PAL (European, Phase Alternating Line) composite video format and shall be digitized and analyzed in real time. Dual video VDP's shall process images from both inputs simultaneously.

The VDP shall detect the presence of vehicles in up to 24 detection zones per camera. A detection zone shall be approximately the width and length of one car.

Detection zones shall be programmed via an on-board menu displayed on a video monitor and a pointing device connected to the VDP. The menu shall facilitate placement of detection zones and setting of zone parameters or to view system parameters. A separate computer shall not be required for programming detection zones or to view system operation.

The VDP shall store up to three different detection zone patterns. The VDP can switch to any one of the three different detection patterns within 1 second of user request via menu selection with the pointing device. Each configuration can be uniquely labeled for identification and the current configuration letter is displayed on the monitor.

The VDP shall detect vehicles in real time as they travel across each detector zone.

The VDP shall have an RS232 port for communications with an external computer. The VDP RS232 port shall be multi-drop compatible.

The VDP shall accept new detector patterns from an external computer through the RS-232 port when the external computer uses the correct communications protocol for downloading detector patterns. A Windows™-based software designed for local or remote connection and providing video capture, real-time detection indication and detection zone modification capability shall be provided with the system.

The VDP shall send its detection patterns to an external computer through the RS-232 port when requested when the external computer uses the appropriate communications protocol for uploading detector patterns.

The extension module (EM) shall be available to avoid the need of rewiring the detector rack, by enabling the user to plug an extension module into the appropriate slot in the detector rack. The extension module shall be connected to the VDP by an 8-wire cable with modular connectors. VDP and EM communications shall be accommodated by methods using differential signals to reject electrically coupled noise. The extension module shall be available in both 2 and 4 channel configurations. EM configurations shall be programmable from the VDP. I/O module 24 outputs – 8 inputs using external wire harness for expanded flexibility.

The camera system shall be able to transmit the composite video signal, with minimal signal degradation, up to 325 m under ideal conditions.

The associated VDP shall default to a safe condition, such as a constant call on each active detection channel, in the event of loss of video signal.

The system shall be capable of automatically detecting a low-visibility condition such as fog and respond by placing all defined detection zones in a constant call mode. A user-selected output shall be active during the low-visibility condition that can be used to modify the Controller operation if connected to the appropriate Controller input modifier(s). The system shall automatically revert to normal detection mode when the low-visibility condition no longer exists.

1604.03.7.3 Vehicle Detection

A minimum of 24 detection zones shall be supported and each detection zone shall be user definable in size and shape to suit the site and the desired vehicle detection region.

A single detection zone shall be able to replace multiple inductive loops and the detection zones shall be OR'ed as the default or may be AND'ed together to indicate vehicle presence on a single phase of traffic movement.

Placement of detection zones shall be done by using only a pointing device, and a graphical interface built into the VDP and displayed on a video monitor, to draw the detection zones on the video image from the video camera. No separate computer shall be required to program the detection zones.

A minimum of 3 detection zone patterns shall be saved within the VDP memory. The VDP's memory shall be non-volatile to prevent data loss during power outages. The VDP shall continue to operate (e.g. detect vehicles) using the existing zone configurations even when the operator is defining/modifying a zone pattern. The new zone configuration shall not go into effect until the configuration is saved by the operator.

The selection of the detection zone pattern for current use shall be done through a local menu selection or remote computer via RS-232 port. It shall be possible to activate a detection zone pattern for a camera from VDP memory and have that detection zone pattern displayed within 1 second of activation.

When a vehicle is detected crossing a detection zone, the corners of the detection zone will flash on the video overlay display screen to confirm the detection of the vehicle.

Detection shall be at least 98% accurate in good weather conditions and at least 96% accurate under adverse weather conditions (rain, dust storm, or fog). Detection accuracy is dependent upon site geometry; camera placement, camera quality and detection zone location, and these accuracy levels do not include allowances for occlusion or poor video due to camera location or quality.

Detector placement shall not be more distant from the camera than a distance of ten times the mounting height of the camera.

The VDP shall provide up to 24 channels of vehicle presence detection per camera through a standard detector rack edge connector and one or more extension modules.

The VDP shall provide dynamic zone reconfiguration (DZR) to enable normal detector operation of existing channels except the one where a zone is being added or modified during the setup process. The VDP shall output a constant call on any detection channel corresponding to a zone being modified.

Detection zone setup shall not require site specific information such as latitude, longitude, date and time to be entered into the system.

The VDP shall output a constant call for each enabled detector output channel if a loss of video signal occurs. The VDP shall output a constant call during the background learning period.

Detection zone outputs shall be configurable to allow the selection of presence, pulse, extend, and delay outputs. Timing parameters of pulse, extend, and delay outputs shall be user definable between 0.1 to 25.0 seconds.

Up to six detection zones shall be capable to count the number of vehicles detected. The count value shall be internally stored for later retrieval through the RS-232 port. The data collection interval shall be user definable in periods of 5, 15, 30 or 60 minutes.

1604.03.7.4 VDP and EM Hardware

The VDP and EM shall be specifically designed to mount in a standard NEMA TS-1, TS-2, 2070 ATC, 170 type detector rack, using the edge connector to obtain power and provide contact closure outputs. No adapters shall be

required to mount the VDP or EM in a standard detector rack. Detector rack rewiring shall not be required or shall be minimized.

The VDP and EM shall operate in a temperature range from -34°C to +74°C and a humidity range from 0%RH to 95%RH, non-condensing.

The VDP and EM shall be powered by 12 or 24 V DC. These modules shall automatically compensate for the different input voltages.

VDP power consumption shall not exceed 300 milliamps at 24 VDC. The EM power consumption shall not exceed 120 milliamps at 24 VDC.

The VDP shall include an RS232 port for serial communications with a remote computer. The VDP RS232 port shall be multi-drop compatible. This port shall be a 9-pin "D" subminiature connector on the front of the VDP.

The VDP shall utilize flash memory technology to enable the loading of modified or enhanced software through the RS232 port without modifying the VDP hardware.

The VDP and EM shall include detector output pin out compatibility with industry standard detector racks.

The front of the VDP shall include detection indications, such as LED's, for each channel of detection that display detector outputs in real time when the system is operational.

The front of the VDP shall include one or two BNC video input connection suitable for RS170 video inputs as required. The video input shall include a switch selectable 75-ohm or high impedance termination to allow camera video to be routed to other devices, as well as input to the VDP for vehicle detection. Video must be inputted via a BNC connector on the front face of the processor. RCA type connectors/jacks for video input are not allowed. Video shall not be routed via the edge connectors of the processor.

The front of the VDP shall include one BNC video output providing real time video output that can be routed to other devices. A RCA type connector/jack for video output is not allowed.

The front panel of the VDP and EM shall have a detector test switch to allow the user to place calls on each channel. The test switch shall be able to place either a constant call or a momentary call depending on the position of the switch.

1604.03.7.5 Video Detection Camera

Video detection cameras used for traffic detection shall be furnished by the video detection processor (VDP) supplier and shall be qualified by the supplier to ensure proper system operation.

The camera shall produce a useable video image of the bodies of vehicles under all roadway lighting conditions, regardless of time of day. The minimum range of scene luminance over which the camera shall produce a useable video image shall be the minimum range from nighttime to daytime, but not less than the range 0.1 lux to 10,000 lux.

The camera shall use a CCD sensing element and shall output monochrome or color video with resolution of not less than 380 lines horizontal.

The camera shall include an electronic shutter control based upon average scene luminance and shall be equipped with a factory adjusted manual iris. Auto-iris lenses are not allowed.

The camera shall be offered with two lens configurations. One configuration shall include a variable focal length lens and the other with a fixed focal length wide angle lens.

Variable Focal Length Lens Camera - The camera shall include a variable focal length lens with variable focus that can be adjusted, without opening up the camera housing, to suit the site geometry by means of a portable interface device designed for that purpose and manufactured by the detection system supplier. The horizontal field of view shall be adjustable from 8.1° to 45.9°. This camera configuration may be used for the majority of detection approaches in order to minimize the setup time and spares required by the user.

Wide Angle Lens Camera – The camera shall include a fixed focal length lens with fixed focus to enable camera installations without lens adjustments. The horizontal field of view shall be 60° minimum to facilitate multi-lane video detection in instances where mounting heights or viewing angles are constraining geometric factors.

The camera electronics shall optionally include automatic gain control (AGC) to produce a satisfactory image at night.

The camera shall be housed in a weather-tight sealed enclosure. The enclosure shall be made of 6061 anodized aluminum. The housing shall be field rotatable to allow proper alignment between the camera and the traveled road surface.

The camera enclosure shall be equipped with a sunshield. The sunshield shall include a provision for water diversion to prevent water from flowing in the camera's field of view. The camera enclosure with sunshield shall be less than 153 mm diameter, less than 381 mm long, and shall weigh less than 2.75 kg when the camera and lens are mounted inside the enclosure.

The camera enclosure shall include a thermostatically controlled heater to assure proper operation of the lens functions at low temperatures and prevent moisture condensation on the optical faceplate of the enclosure.

When mounted outdoors in the enclosure, the camera shall operate satisfactorily in a temperature range from -34°C to +60°C and a humidity range from 0% RH to 100% RH. Measurement of satisfactory video shall be based upon VDP system operation.

The camera shall be powered by 240 VAC 50Hz. Power consumption shall be 15 watts or less under all conditions. An optional dual power configuration shall be available to facilitate either 240 AC or 12 VDC operation.

Recommended camera placement height shall be 10 m above the roadway, and over the traveled way on which vehicles are to be detected. For optimum detection the camera should be centred above the traveled roadway. The camera shall view approaching vehicles at a distance not to exceed 100 m for reliable detection (height to distance ratio of 10:100). Camera placement and field of view (FOV) shall be unobstructed and as noted in the installation documentation provided by the supplier.

The camera enclosure shall be equipped with separate, weather-tight connections for power and video cables at the rear of the enclosure. These connections may also allow diagnostic testing and viewing of video at the camera while the camera is installed on a mast arm or pole using a lens adjustment module (LAM) supplied by the VDP supplier. Video and power shall not reside within the same connector.

Multiple camera configurations shall be available to support composite monochrome or color video output in either NTSC or PAL standards.

The video signal shall be fully isolated from the camera enclosure and power cabling.

1604.03.7.6 Warranty

The Sub-contractor shall provide two-year warranty on the video detection camera.

During the warranty period, technical support shall be available from the Sub-contractor via telephone within 4 hours of the time a call is made by a user

Updates to VDP software available from the supplier shall be delivered by the Sub-contractor without charge to the Employer/MOI during the warranty period.

1604.03.7.7 Maintenance and Support

The Sub-contractor shall maintain an adequate inventory of parts to support maintenance and repair of the video detection camera. These parts shall be available for delivery within 30 days of placement of an acceptable order. Rates for parts required beyond the Maintenance Period are to be agreed with the user.

The Sub-contractor shall maintain an ongoing program of technical support for the video detection system. This technical support shall be available via telephone, or via personnel sent to the installation site upon request by the user. Rates for technical support beyond the Maintenance Period are to be agreed with the user.

Installation or training support shall be provided by a factory-authorized representative of the supplier.

All product documentation shall be written in the English language.

1605 - CABLES AND WIRING

1605.01 GENERAL

The Sub-contractor shall be responsible for the design and installation of all cabling and wiring.

1605.02 DEFINITIONS

Power Cable - From the point of mains supply by the Ministry of Electricity and Water to the Controller.

Signal Aspect Cable - From the Controller to the signal head housing.

Pedestrian Push Button Cable - From the Controller to the pedestrian push button and pedestrian push button indicators.

Alternate Flashing Light Signal Control Cable - From a remote control centre to the Controller.

Internal Wiring - Within the control itself.

Lead-in Wiring - From the road loop to the detector.

1605.03 POWER CABLE

The power cable shall be armoured 750 V, 75°C copper conductor, polyethylene (PE) insulated, PVC over-sheathed conforming to the applicable requirements of British Standard (BS), IMSA, or IEE. It shall be a 3-core electric service cable and shall consist of stranded copper conductors, circular in shape, PE insulated and PVC oversheathed. Phase and neutral conductors shall be 16 mm^2, and the earth core shall be 6 mm^2.

1605.04 SIGNAL ASPECT CABLE

The signal aspect cable shall be armoured, 750 V, 75°C copper conductor, polyethylene (PE) insulated, PVC oversheathed conforming to the applicable requirements of British Standard (BS), IMSA or IEE. It shall consist of solid copper conductors, soft drawn circular in shape, PE insulated and PVC oversheathed. All cores (signal phases and neutral) shall be 1.5 mm^2. A minimum of 3 spare cores shall be provided throughout each cable run.

Where two signals displaying the same indications simultaneously are mounted on the same support, the first signal shall be connected by signal aspect cable to the terminal block in the Controller cabinet. The second signal shall be connected by signal aspect cable to a terminal block in the first signal, unless shown otherwise on the Drawings.

1605.05 CABLE REQUIREMENTS

The following requirements relate to both power and signal aspect cables:

1605.05.1 Alternative Cables

Cables conforming to comparable international standards may be considered by the MOI/Engineer. All applicable tests listed in BSEN 60228 shall be performed on the cable at the manufacturer’s plant and certified test results shall be submitted to the MOI/Engineer.

1605.05.2 Insulation and Sheathing

Heat resisting polyethylene shall be used for insulating conductors and thickness shall be according to BSEN 60228 or IMSA 19.3.

Non-hygroscopic fillers shall be applied with the sheath of the cables. The sheath shall be a black polyvinyl chloride 2.2 mm thick,of an approved international standard. Negative tolerance of the sheath shall be according to BS EN 60228.

1605.05.3 Identification of Cores

All cores shall be coloured for identification. The Sub-contractor shall follow the list of colours for each type of cable as shown in Table 16.05.3. In the event that any cable is furnished on two or more drums, the same colour coding must be used throughout the stock of that cable.

Circuit	Signal Phase or Function	Identification			Size
		Insulation Colors		Band Symbols (b) (f)	
		Base	Stripe(a)		
Vehicle Signals (d)	2, 6	Red, Yellow, Brown	Black	2, 6	14
	4, 8	Red, Yellow, Brown	Orange	4, 8	14
	1, 5	Red, Yellow, Brown	None	1, 5	14
	3, 7	Red, Yellow, Brown	Purple	3, 7	14
	Ramp Meter 1	Red, Yellow, Brown	None	No Brand Required	14
	Ramp Meter 2	Red, Yellow, Brown	Black	No Brand Required	14
Pedestrian Signals (d)	2p, 6p	Red, Brown	Black	2p, 6p	14
	4p, 8p	Red, Brown	Orange	4p, 8p	14
	1p, 5p	Red, Brown	None	1p, 5p	14
	3p, 7p	Red, Brown	Purple	3p, 7p	14
Pedestrian Push buttons (d)	2p, 6p	Blue	Black	P-2, P-6	14
	4p, 8p	Blue	Orange	P-4, P-8	14
	1p, 5p	Blue	None	P-1, P-5	14
	3p, 7p	Blue	Purple	P-3, P-7	14
Traffic Signal Controller Cabinet	Ungrounded between Service	Black	None	CON-1	6
	Grounded Circuit Conductor	White	None	CON-1	6
Highwway Lighting Pull Box to Luminaire (i)	Ungrounded-Line 1	Black	None	No Brand Required	14
	Ungrounded-Line 2	Red	None	No Brand Required	14
	Grounded	White	None	No Brand Required	14
Multiple Highway Lighting	Ungrounded-Line 1	Black	None	ML1	10
	Ungrounded-Line 2	Red	None	ML2	10
Lighting Control	Ungrounded to Photoelectric Unit	Black	None	C1	14

Table 16.05.3: Conductor Identification

	Switching leg from Photoelectric unit or SM transformer	Red	None	C2	14
Multiple Service	Ungrounded-Line 1 (Signals)	Black	None	No Brand Required (e)	6
	Ungrounded-Line 2 (Lighting)	Red (j)	None	No Brand Required (e)	8
Sign Lighting (h)	Ungrounded-Line 1	Black	None	SL-1	10
	Ungrounded-Line 2	Red	None	SL-2	10
Flashing Beacons (g)	Ungrounded between Flasher and Beacons	Red or Yellow	None	F-Loc. (c)	14
Grounded and Common	Pedestrian Push Buttons	White	Black	No Brand Required	14
	Signals and Multiple Lighting	White	None	No Brand Required	10
	Flashing Beacons and Sign Lighting	White	None	No Brand Required	12
	Lighting Control	White	None	C-3	14
	Multiple Service	White	None	No Brand Required	14
Spares		Black	None	No Brand Required	14

Table 16.05.3: (Cont`d) Conductor Identification

a On overlaps, insulation is striped for first phase in designation. E.g., phase (2+3) conductor is striped as for phase 2.

b Band for overlap and special phases as required.

c Flashing beacons having separate service do not require banding.

d These requirements do not apply to signal cable.

e "S" if circuit is switched on line side of service equipment by utility.

f Band conductors in each pull box and near ends of termination points. On signal light circuits, a single band may be placed around 2 or 3 ungrounded conductors comprising a phase.

g Ungrounded conductors between service switch and flasher mechanism shall be black and banded.

h Conductors between ballasts and sign lighting lamps shall be No. 16 and color shall correspond to the ballast leads.

i Both conductors between external high intensity discharge (H.I.D.) ballast and lamp socket shall be black.

j Black acceptable for size No. 2 and larger. Tape ends for 20 inches with indicated color.

1605.06 PEDESTRIAN PUSH BUTTON CABLE

Cabling for pedestrian push buttons and indicators shall be achieved by utilising separate cores in the Signal Aspect Cable.

1605.07 ALTERNATE FLASHING LIGHT SIGNAL CONTROL CABLE

Where direct connection between the remote station and Controller is required, cabling shall be achieved by using cable meeting the requirements of Clauses 1605.04 and 1605.05 of these Specifications except that 4 cores shall be provided.

1605.08 INTERNAL WIRING

1605.08.1 General

Internal wiring for the Controller shall consist of connecting to its terminals:

a. The wires of the cables leading to the detectors and to the signals, push buttons and push button indicators.
b. The power wires.
c. The ground wires.
d. The wires of the cables from any other equipment external to the Controller as detailed on the Drawings.
e. All spare wires.

All spare wires shall be placed on special terminal blocks to be mounted by the Sub-contractor in the cabinet for this purpose.

Other wiring for the Controller shall be as required by the wiring diagrams and instructions furnished with the Controller by the manufacturer.

1605.08.2 Solid Conductor Requirements

Solid conductors and wiring shall conform to all applicable portions of the National Electrical Code (NEC), or approved alternative. Insulation shall be polyvinyl chloride compound conforming to the specifications of ASTM D2219 and D2220, TW grade for conductors No. 14 AWG (2.0 mm^2) and larger, and TF grade for No. 16 AWG (1.3 mm^2) conductors and smaller, or approved alternative.

1605.08.3 Stranded Conductor Requirements

All conductors subject to flexing during opening of cabinet doors or removal of Controllers shall be stranded. Stranded conductors No. 14 AWG (2.0 mm^2) to No. 10 AWG (5.3 mm^2) inclusive shall be 19 strands and conductors No. 16 AWG (1.3 mm^2) and smaller shall be 26 strands.

1605.08.4 Power Conductors in Controller Cabinet

Conductors between service terminals and the “AC+” terminals to signal light relays, bus terminals, and the signal light neutral shall be No. 10 AWG (5.3 mm^2) or larger.

1605.08.5 Splices Prohibited

No splices will be permitted inside the Controller cabinet.

1605.09 LEAD-IN WIRING

Lead-In wiring shall comply with Clause 1604.03.3 of these Specifications.

1605.10 TERMINALS

The ends of all wires which are to be attached to terminal blocks of the barrier screw type shall be provided with solderless terminals that meet the requirements of the Kuwait Electrical Code and shall be of the pre-insulated positive grip type.

1606 - DUCTS AND UNDERGROUND STRUCTURES

1606.01 DUCTS

Unless otherwise shown on the Drawings, ducts under the carriageway shall comprise a group of 4 No. 100 mm diameter PVCu pipes. Ducts under the footway housing lead-in wires from vehicle detector loops to the Controller shall be 50 mm diameter PVCu pipes.

The pipes shall comply with the specification for unplasticised PVC pipes given in Section 21 (Telephone Network) of these Specifications.

1606.02 UNDERGROUND STRUCTURES

Underground Structures include junction boxes and handholes. These structures shall be constructed of concrete cast in place. The Sub-contractor may submit to the MOI/Engineer for consideration and approval structures constructed in the alternative materials of precast concrete or pre-formed fibreglass. Detail construction drawings for each type of structure shall be submitted by the Sub-contractor for approval by the MOI/Engineer prior to installation. Sizes may vary slightly from the recommended subject to the approval of the MOI/Engineer.

1606.03 JUNCTION BOXES

Junction boxes shall be provided where cable runs and/or duct runs intersect. Internal dimensions shall be 900 x 900 x 1000 mm (maximum) deep, or where cables enter and leave the box on approximately the same alignment, may be reduced to a minimum of 900 x 450 x 500 mm deep. Junction boxes shall be constructed from Class K300 concrete with the bottom trowelled smooth, and shall be fitted with watertight covers supplied by the Sub-contractor. Covers and frames located in roadways shall be designed to withstand a 14 tonne test load. The covers shall incorporate the legend ‘ATC’.

1606.04 HANDHOLES

Handholes shall be provided at joints in detector cable circuits and elsewhere where cables are small or light in weight. Their internal dimensions shall be 300 x 300 x 800 mm (maximum) deep, and they shall be constructed from Class K300 concrete with the bottom trowelled smooth. Handholes shall be fitted with watertight covers supplied by the Sub-contractor.

1606.05 DUCT STUBS

Walls of junction boxes not penetrated by ducts shall be provide with 4 no. 100 mm duct stubs, where space permits to allow for future connections. Stubs shall be plugged or capped to prevent seepage of water into the box.

1606.06 DRAINAGE OF JUNCTION BOXES

Junction boxes shall be provided with a dry well for drainage purposes. The dry well shall be placed under the junction box and its volume shall not be less than 50% of the volume of the box. It shall be filled with coarse aggregate complying with Clause 501.04 of Section 5 (Concrete Works) of these Specifications. The Sub-contractor shall submit designs for junction box drainage to the MOI/Engineer for approval.

1607 - INSTALLATIONS OUTSIDE THE ATC AREA

1607.01 GENERAL

For signals to be installed in locations outside the present or likely future extent of the Kuwait Area Traffic Signal, certain relaxations may and additions shall, be made. These shall only be effected for installations clearly marked on the Drawings with the words “non-ATC installation”.

1607.02 RELAXATIONS

The following relaxations are permitted in the Non-ATC installations:

a. Clause 1602.01 (f) (g) and (n) - Delete

b.	Clause 1602.02 (a)	-	Delete "(a) Computer Control"
c.	Clause 1602.02.1	-	Delete
d.	Clause 1602.02.2	-	Delete the first two sentences and (a) and (c) in the third paragraph
e.	Clause 1602.02.3	-	Delete all after "maintained" and replace by "or when selected through the local test switch"
f.	Clause 1602.02.4	-	Delete the latter part of the second paragraph after the words "police panel"
g.	Clause 1602.02.5	-	Delete (c) in the second paragraph
h.	Clause 1602.02.10	-	Delete (ii)
i.	Clause 1602.05.14	-	Delete second sentence
j.	Clause 1602.05.22	-	Delete from the 4th sentence onwards
k.	Clause 1602.05.25	-	Delete
l.	Clause 1602.09.2	-	Delete the words "associated OTU"
m.	Clause 1602.09.3	-	Delete third sentence of second paragraph.
n.	Clause 1602.09.4	-	Delete paragraph (c)
o.	Clause 1602.09.7	-	Only one socket outlet is to be provided (for maintenance and test purposes) and this Clause shall be read accordingly.
p.	Clause 1602.09.11	-	Delete the words "and data transmission cables to the OTU".

1607.03 ADDITIONAL REQUIREMENTS

The following additional requirements shall apply in non-ATC installations:

1607.03.1 Vehicle Detector Malfunction

An external vandal-resistant lamp shall be provided on the Controller cabinet. Operation of the vehicle actuation detector monitor shall cause this light to illuminate if a detector appears to be defective. The following features shall be provided:

a. The lamp shall remain illuminated for so long as the detector fault persists, and shall be extinguished when satisfactory operation resumes.

b. Means shall be provided in the Controller for manually testing that the lamp circuit is serviceable.

c. The lamp shall be of a different colour to the signal specified in Clause 1602.09.8 of these Specifications, and from the lamp specified in Clause 1602.09.3 of these Specifications if provided.

1607.03.2 Power Failure

Further to the provisions of the Clause 1602.08.5 (b) of these Specifications an external vandal-resistant lamp shall be provided on Controller cabinets at signalised intersections. This lamp shall be illuminated when power is restored after a period of mains supply interruption which has caused the Controller to lose synchronisation. The following features shall be provided:

a. The lamp shall remain illuminated from the time of loss of synchronisation until manually cancelled. Means of cancelling shall be provided in the Controller.

b. Means shall also be provided to test the operation of this system without interrupting the power supply to the Controller.

c. The lamp shall be of a different colour to that specified in Clause 1607.03.1 of these Specifications and the provisions of Clause 1607.03.1 (c) of these Specifications shall also apply to this lamp.

1607.04 FUTURE ATC EXTENSION

Where signalised installations are to be incorporated into the ATC system at some future date, such installations being either inside or outside the ATC area, the additions of Clause 1607.03 of these Specifications may be required without the relaxations of Clause 1607.02 of these Specifications. If this is the case, it will be clearly stated on the Drawings, and the Sub-contractor shall provide accordingly.

1607.05 SIGNALISED INTERSECTIONS WITHOUT DETECTION

Where no vehicle detectors or pedestrian detectors are shown on the Drawings for any particular installation, then pretimed operation as defined in Clause 1602.05.8 of these Specifications applies, and the Sub-contractor may make the following relaxations:

a.	Clause 1602.05.15	Delete
b.	Clause 1602.05.21	Delete the last paragraph
c.	Clause 1602.05.26	Delete
d.	Clause 1604	Delete
e.	Clause 1605.02	Delete definitions of pedestrian push button cable, Alternate Flashing Light signal control cable and lead-in wiring.
f.	Clause 1605.06	Delete
g.	Clause 1605.07	Delete
h.	Clause 1605.09	Delete
i.	Clause 1607.03.1	Delete

1608 - INSTALLATION AND ERECTION OF AUTOMATIC TRAFFIC SIGNALS

1608.01 GENERAL REQUIREMENTS

The entire installation including excavation, backfilling, cable laying and erection work associated with the automatic traffic signals shall be carried out entirely by the Sub-contractor.

The Ministry of Electricity and Water will provide one single point of electrical supply at or near the final approved position of the Controller, for each installation. All other works required shall be the responsibility of the Sub-contractor.

All installation and erection works shall be carried out in such a manner that all current regulations in respect of safety are fully complied with.

1608.02 MATERIALS

Subject to the provisions of Clause 1600.02 of these Specifications, the Sub-contractor shall:

a. be responsible for the supply of all materials necessary for the satisfactory completion of the Traffic Signal.
b. be responsible for storage of all such materials, delivery to site and installation.

Provide the following additional materials and service required in connection with the installation and erection works:

a. all installation material, accessories and components which will be required for the installation and commissioning of the automatic traffic signals.
b. included in his Contract Price shall be all such minor accessories, components and materials which may not be specifically mentioned, but which are required for the operation of the system as a whole. No extra payments will be allowed for the employment of any materials, accessories or components, which are necessary for the completion of the scheme.

1609 - POWER SUPPLY TO CONTROLLERS

1609.01 ARRANGEMENTS FOR SUPPLY

The Contractor/Sub-contractor shall be responsible for making the necessary arrangements with the Electrical Distribution Network Section of the Ministry of Electricity and Water (MEW) for the connection of the Traffic Signal to the power supply network. A formal application for connection must also be made to MEW through the MOI/Engineer. Adequate notice shall be given to the MOI/Engineer to permit the processing of this application.

Connection to the network will be carried out by MEW. Neither connection charges nor traffic signal power supply charges will be made to the Contractor/Sub-contractor.

All regulations of the Ministry of Electricity and Water shall be strictly observed in the distribution and use of the supply. Under no circumstances shall any installation be connected to the mains supply until authorised by the MOI/Engineer.

The nominal voltage of the mains power to be supplied by the Ministry of Electricity and Water is 240 V, single phase at a nominal frequency of 50 Hz.

1609.02 EXISTING SIGNAL INSTALLATIONS

At locations where the existing Controller is being replaced by a new Controller, the existing power mains shall be replaced if necessary, and re-routed to the new Controller cabinet. Should the position of the new cabinet require the new power cable to traverse a road, the Sub-contractor shall lay a 100 mm diameter PVC duct to the requirements of Clause 1614 of these Specifications and the cable shall be laid within the duct. The Sub-contractor shall obtain approval of the Ministry of Electricity and Water before commencing any work on the relocation of the power cables.

1609.03 NEW SIGNAL INSTALLATIONS

For locations that are being signalised for the first time under this Contract, the Sub-contractor shall make arrangements for the power supply connection with the Ministry of Electricity and Water. The connection shall be at a point as near to the Controller as practicable. The Sub-contractor shall furnish and install all other materials necessary to make the power connection that are not furnished by the Ministry of Electricity and Water. The Sub-contractor shall install any necessary 100 mm or 50 mm PVC duct. Before undertaking any work on the new power connection, the Sub-contractor shall obtain the approval of the Ministry of Electricity and Water.

1610 - INSTALLATION OF CONTROLLERS

1610.01 LOCATION

The Controllers and cabinets supplied under this Contract shall be installed in the location shown on the Drawings, or in the case of existing signal installations as close to the existing location as is practical.

1610.02 FOUNDATIONS

Foundations shall be constructed in accordance with the requirements of Section 5 (concrete works) of these Specifications.

1610.03 EXISTING INSTALLATIONS

The Sub-contractor shall establish a procedure for replacing the existing signal hardware and Controllers with the required new facilities with a minimum disruption to the normal flow of traffic. This procedure shall be approved by the MOI/Engineer prior to its implementation.

1610.04 PAINTING

No field painting of cabinets shall be undertaken.

1611 - INSTALLATION OF SIGNAL HEADS AND SUPPORTS

1611.01 FOOTINGS

Footings for signal poles, pedestals and overhead masts shall be constructed in accordance with Sections 2 and 5 (Earthworks and Concrete Works) of these Specifications. The following procedures and requirements shall apply.

a. The excavation shall conform to the neat lines of the footing and the use of forms shall not be permitted except when the footing is above the existing surface and then with the approval of the MOI/Engineer.

b. Footings shall incorporate raceways for underground cable entries, terminating in a circular opening of at least 150 mm diameter at the centre, and the ground rods.

c. Class K300 concrete shall be placed to the desired level and trowel finished.

d. All concrete bases shall be allowed to attain the design strength before any structures are installed thereon.

e. Anchor bolts shall be accurately set with a template furnished by the pole manufacturer.

f. When the signal support has been installed to the correct level and rake, the space between the concrete base and pole base plate shall be filled using a pre-bagged proprietary, non-shrink, free-flowing, cementitious grout, neatly finished and chamfered.

1611.02 LOCATIONAL TOLERANCE

When installation is completed, the poles, pedestals, equipment, and uprights shall be in the positions shown on the Drawings. Drawings are schematic only, final location of poles, pedestals, equipment and uprights shall be approved by the MOI/Engineer in the field.

1611.03 INSTALLATION OF SIGNAL SUPPORTS

1611.03.1 Installation Procedure

Nut shall be screwed onto the anchor bolts and adjusted to the approximate level for the support base. The support shall then be set in position and the nuts adjusted to set the support to the correct level and rake. The use of shims or other levelling devices shall not be permitted.

Securing nuts shall then be screwed down to the required torque, the space between concrete base and base plate infilled with the specified grout and all hardware and fittings installed as shown on the manufacturer's drawings.

1611.03.2 Rake

Uprights of overhead masts shall be installed with the proper "rake" as recommend by the manufacturers so as to assure a substantially vertical set after the load is applied.

Pedestals and poles supporting only a vertical dead load shall be installed vertically.

1611.03.3 Overhead Masts

Mast arms shall be securely attached to uprights in a manner which minimises the risks of rotation or slippage relative to the upright.

1611.03.4 Painting

After erection, the Sub-contractor shall paint the outside of each pole, pedestal, upright and mast arm in accordance with Clause 1202.10 of Section 12 (Metalworks) of these Specification. The proposed paint specification and colour shall be submitted to the MOI/Engineer for approval before application. Signal heads shall not be painted.

1611.03.5 Numbering

Each pole, pedestal and upright shall be clearly identified with a number as determined by the MOI/Engineer. The identifying number shall be applied in black paint using stencil numerals of at least 50 mm in height.

1611.03.6 Other Supports

Signals mounted on gantries or on structures shall be installed in a manner complying with relevant parts of Clauses 1611.03.1, 1611.03.2, 1611.03.3, and 1611.03.4 and Clause 1611.04 of these Specifications and in accordance with the relevant Drawings.

1611.04 INSTALLATION OF SIGNAL HEADS

Signal heads shall be securely and adequately attached to their supports by a means complying with Clause 1603.02.2 of these Specifications. They shall be adjusted to face oncoming traffic.

Overhead signals shall be mounted such that the lowest point of the signal head assembly, including backing board, is at least 5.5 m above the level of the roadway. Other signals shall be mounted such that the lowest point of the signal head assembly is between 2.3 m and 2.9 m above the level of the roadway.

1611.05 INSTALLATION OF PEDESTRIAN PUSH BUTTONS

Push buttons shall be securely and adequately attached to their supports. The height of the button above and adjacent footway shall be between 1.2 m and 1.5 m.

1611.06 INSTALLATION OF ALTERNATE FLASHING LIGHT SIGNAL PUSH BUTTONS

The method and position of fixing of push buttons shall be as shown on the Drawings or as approved by the MOI/Engineer.

1612 - INSTALLATION OF VEHICLE DETECTORS

1612.01 GENERAL

The Sub-contractor shall conform to the requirements for supplying and installing loop and lead-in wire for the loop detector. The installation requirements include saw cuts, loop and lead-in wires, and sealing.

The Sub-contractor shall submit details of the design; including loop configuration, loop slot filling procedures, and any special requirements for the installation of loops or lead-in wiring, to the MOI/Engineer for approval.

1612.02 SAW CUTS

The Sub-contractor shall slot the roadway using a diamond or abrasive saw blade of approximately 8 mm width. Slots shall be cut to the following minimum depths:

Number of Wires in Slot	Concrete Surface Roadway	Asphalt Surface Roadway
1 - 3	37 mm	65 mm
4 - 5	50 mm	80 mm

The saw cuts shall be overlapped so that the slot has full depth at all turns. No turns shall be at an included angle of more than approximately 45°. Where turns of 90° are anticipated, a 45° diagonal shall be cut between the perpendicular cuts beginning 500 mm from the theoretical intersection of the perpendiculars. Two or three turns (or as specified by the detector manufacturer) of wire shall be installed in the saw cut.

Prior to installation of the wire, the saw cut shall be fully cleaned by air pressure. There shall be no cutting dust, grit, oil, moisture or other contaminations in the saw cut.

Saw cutting of curbs shall not be permitted.

Permitted tolerances on location dimensions shown for loops on the Drawings shall be:

a. For dimensions up to 18 m: - 0.25 m + 0 m

b. For dimensions over 18 m: - 0.50 m + 0 m

1612.03 LOOP AND LEAD-IN WIRES

Immediately prior to installation, the loop wire shall be inspected for any cuts, breaks and nicks in the insulation, and a film of sealer shall be applied to the bottom of the slot. If any damage exists, the damaged portion of wire shall not be used. The wire shall be installed at the bottom of the saw cut slot. A piece of wood shall be used to seat the wire at the bottom of the slot. In no case shall a screw driver or both sharp object be used for this purpose. This wire shall be laid in the slot so that there are no binds or curls and no straining or stretching of the insulation around the corners of the slot or into the handhole. After placing the wire in the slot, it shall be rechecked for slack, raised portions and tightness. If any of the foregoing are found, they shall be corrected before the sealer is applied. The wire shall be installed and supported so that the sealer completely encapsulates the wire in the slot.

The two wires from the loop shall be twisted together with a minimum of three turns per metre from the loop itself to the handhole located behind the kerb, and shall be protected by a 50 mm diameter PVC duct as they pass beneath the kerb.

The handhole shall be connected to the Controller cabinet with a 50 mm diameter PVC duct, and lead-in wires shall be installed in this duct. They shall be uniquely identified by an insulated pre-painted sleeve slipped over the wire before attachment of a lug connector. Each roadway loop shall have a separate pair of wires for the lead-in to the detector.

1612.04 TESTS

The loop and lead-in wires shall be tested separately and together prior to installation of the slot sealer, for continuity, series resistance, and for impedance to earth ground. Assemblies having less than ten ohms series resistance and more than 10 mega ohm impedance to earth ground shall be sealed. After the slot sealer has cured, the assembly shall be tested to ensure that the high voltage (greater tan 400 V) impedance to earth ground again shall be greater than 10 mega ohm. Assemblies failing either of these tests shall be replaced by the Sub-contractor at his expense.

Assemblies passing these tests shall be tested to ensure that the total series inductance is in the range of 50 to 700 micro-henrys at 50 KHz.

1612.05 SEALING SAW CUTS

The saw cut shall be sealed with a two-component synthetic base epoxy resin flexible embedding sealer. When used in an asphalt surfaced road, the sealer shall not be affected by the asphalt or react with it. The sealer shall have a minimum tensile strength of 8300 kN/m2 and shall exhibit an adhesion to concrete of at least 2075 kN/m^2. The viscosity of the sealer shall be such that it can be readily poured into the saw cut. In addition to these Specifications, the Sub-contractor shall strictly adhere to the sealer manufacturer's directions, specifications and application bulletins, relating to application, pouring and installation of the sealer.

Prior to installation of the sealer, the Sub-contractor shall ensure that no moisture and/or other contaminants are present in the saw cut. The saw cut shall be completely cleaned and dried again if necessary. The sealer shall not be poured into saw cuts during or immediately following rain.

The Sub-contractor shall ensure that the saw cut is completely filled with sealer and that there are no air bubbles in the sealer below the surface. The sealer shall completely surround the wires and completely fill the slot. The sealer shall be placed in the clean, dry saw cut with minimum spillage onto the roadway outside the saw cut. Any sealer on the roadway, not in the saw cut, shall be removed by the Sub-contractor at his own expense.

All saw cuts filled with cured sealer shall be water and moisture proof. The wires confined within the slot shall not move when subject to traffic vibrations. Cured sealer in the saw cut slot shall be securely bonded to the adjacent paving materials. The sealer shall have sufficient strength and resiliency to withstand stresses set up by normal vibration and expansion and contraction due to temperature changes.

The Sub-contractor shall ensure that the sealer has hardened sufficiently before allowing traffic to move over the area.

1612.06 SEALING THE HANDHOLE SPLICE

After all tests have been performed and the lead-in and loop wire installations found satisfactory, the splice in the handhole between the lead-in and the loop wire shall be made permanent and sealed in the following manner. The splice shall be crimped and soldered and shall then be sealed using a commercial splice sealing kit. The method of sealing splices shall be approved by the MOI/Engineer before use.

The MOI/Engineer may, at his discretion, require the handhole to be flooded with water after sealing and the tests performed again. Test results should not deviate more than 10% under this condition.

1612.07 WIRELESS MAGNETOMETER PRE CONSTRUCTION SITE ANALYSIS

1. The Sub-contractor shall ensure that the installed VSN, RP and AP components will not cause harmful interference to radio communication in the vicinity of the site as required by FCC Part 15 requirements.

2. The Sub-contractor shall ensure that each VSN, RP and AP component shall be installed such that each operates independently and does not interfere with similar components at another site or other equipment in the vicinity of the site.
3. The Sub-contractor shall ensure that each VSN shall be installed within range of its corresponding AP, using RP as needed. All VSN assigned to either an RP or AP shall be located within a +/- 60° horizontal cone, measured from perpendicular. The maximum distances between a VSN and the AP or RP are as follows:

AP / RP mounting height	Maximum distance from VSN
3.7 meters	23 meters
5.5 meters	32 meters
7.3 meters	46 meters

4. The Sub-contractor shall configure and demonstrate successful communication between each VSN, the RP (if necessary) and the AP to the MOI/Engineer prior to the installation of any component.

1612.08 WIRELESS MAGNETOMETER INSTALLATION AND CALIBRATION

All necessary software and equipment needed for the calibration of each WMVDS shall be provided by the Sub-contractor. All software shall operate on a laptop computer running a Windows Operating System recommended by the WMVDS manufacturer.

1. The Sub-contractor shall not proceed with the installation of any component without the written approval from the MOI/Engineer of the Pre-construction Site Analysis.
2. The Sub-contractor shall provide personnel skilled in the installation and calibration of WMVDS components.
3. Prior to installation, the Sub-contractor shall record the VSN ID, its lane number and lane position on the required documentation.
4. The Sub-contractor shall install each VSN in the roadway per manufacturer's recommendations and as shown on the Drawings. Holes cored in the pavement shall be cleaned and thoroughly dried before installing VSN. Residue resulting from core drilling shall not be permitted to flow across shoulders or lanes occupied by public traffic and shall be removed from the pavement surface by vacuuming or other approved method before any residue flows off of the pavement surface. Residue from core drilling shall be disposed of as provided in Clause 1612.09 of these Specifications, Disposal of Residue From Core Drilling. The cored pavement shall be back-filled per manufacturer's recommendations. The Sub-contractor shall remove any excess epoxy from the roadway without the use of solvents and disposed of as provided in Clause 1612.09 of these Specifications, Disposal of Residue From Core Drilling,
5. After installation of both VSN in a lane, the Sub-contractor shall record the center-to-center spacing between the VSN on the required documentation.
6. The Sub-contractor shall install each mounting standard as provided in Section 12 "Metal Works" of these Specifications
7. The Sub-contractor shall install each AP and, if necessary, each RP, per manufacturer's recommendations and as shown on the Drawings.
8. The Sub-contractor shall orient the PV Panel Support Structure as directed by the MOI/Engineer.
9. After installation of all components, the Sub-contractor shall re-configure and demonstrate successful communication between each VSN, the RP (if necessary) and the AP to the MOI/Engineer.

1612.09 WIRELESS MAGNETOMETER DISPOSAL OF RESIDUE FROM CORE DRILLING

The Contractor/Sub-contractor shall dispose of the residue from core drilling in accordance to that described in Clause 102.11 of Section 1 (General) of these Specifications.

1612.10 MAGNETIC DETECTOR INSTALLATION DETAILS

Magnetic detector sensing elements shall be installed within 78 mm, Type 3 conduit, as directed by the MOI/Engineer. Conduit shall extend across the full width of the traveled way (pull box to pull box) as shown on the Drawings. Bottom of conduit shall be placed 0.39 m below top of pavement.

1612.11 VIDEO DETECTOR INSTALLATION

The coaxial cable to be used between the camera and the VDP in the traffic cabinet shall be Belden 8281 or equivalent. This cable shall be suitable for installation in conduit or overhead with appropriate span wire. 75-ohm BNC plug connectors should be used at both the camera and cabinet ends. The coaxial cable, BNC connector, and crimping tool shall be approved by the supplier of the video detection system, and the manufacturer's instructions must be followed to ensure proper connection.

The power cabling shall be 16 AWG three conductor cable with a minimum outside diameter of 0.325 inch and a maximum diameter of 0.490 inch. The cabling shall comply with the National Electric Code, as well as local electrical codes. Cameras may acquire power from the luminaire if necessary.

The camera enclosure shall be equipped with separate, weather-tight connections for power and setup video cables at the rear of the enclosure. These connections may also allow diagnostic testing and viewing of video at the camera while the camera is installed on a mast arm or pole using a lens adjustment module (LAM) supplied by the VDP supplier. Video and power shall not be connected within the same connector.

Recommended camera placement height shall be 10 m above the roadway, and over the traveled way on which vehicles are to be detected. For optimum detection the camera should be centred above the traveled roadway. The camera shall view approaching vehicles at a distance not to exceed 100 feet for reliable detection (height to distance ratio of 10:100). Camera placement and field of view (FOV) shall be unobstructed and as noted in the installation documentation provided by the supplier.

The video detection camera shall be installed by supplier’s factory-certified installers and as recommended by the supplier and documented in installation materials provided by the supplier. Proof of factory certification shall be provided.

1613 - INSTALLATION OF CABLES AND WIRING

1613.01 APPEARANCE OF WIRING

All wiring shall be installed in a neat and workmanlike manner and in conformance with the Kuwait Electricity Safety Code (KESC). Wiring within Controller cabinets shall be cabled together with self-clinching nylon cable ties, waxed lacing, or other method approved by the MOI/Engineer.

1613.02 INSTALLATION OF CABLE

Except at road crossings, or as directed by the MOI/Engineer, all cables shall be laid in trenches at an average depth of 750 mm below finished surface level. The width of the trench shall not exceed 300 mm. Prior to backfilling in accordance with Clause 605.14 of Section 6 (Stormwater Drainage) of these Specifications, the cable shall be protected by earthenware, concrete or other tiles as approved by the MOI/Engineer. At road crossings, and elsewhere as directed by the MOI/Engineer, the cable shall be laid in 100 mm diameter PVC ducts. Powdered soapstone, talc or other approved lubricant shall be used when pulling cable in duct. All cable ends shall be taped to exclude moisture and shall be so kept until splices are made and terminal appliances attached. Ends of spare conductors shall be taped and labelled as spares.

1613.03 TERMINATIONS

Wires shall be attached to terminal blocks by the use of a heavy duty terminal crimp tool with a special ratchet feature which prevents the tool from being opened before the crimp is completed. The terminal crimping tool shall produce transverse crimp on wire. Wires which insert into positive wire insert type terminal blocks will not require terminal connectors.

Soldering of terminal connections to conductors shall be performed in addition to crimping where terminal connections are made to single strand copper solid conductor wires.

1613.04 TAGGING

Numbered identification tags of plastic shall be placed on each wire adjacent to wire ends in the Controller and signal terminal points.

1613.05 PROTECTION

The requirements of Clause 1601.10 of these Specifications shall apply.

1614 - INSTALLATION OF DUCTS AND UNDERGROUND STRUCTURES

1614.01 GENERAL

The Sub-contractor shall lay ducts for cables at road crossings and at other places as directed by the MOI/Engineer. Where cable routes cross the road, ducts shall be laid at right angles to the kerb line. Unless otherwise shown on the Drawings, the depth of the ducts shall be 750 mm below the final surface level, but this depth may be adjusted locally to permit access to handholes and junction boxes. Sides of duct trenches shall be trimmed neatly and the bottom shall be levelled and smoothed and shall not be less than 450 mm in width.

Excavation shall be performed in such a manner as to cause the least possible injury to the streets, footways, driveways, and other facilities. The trenches shall be excavated to the dimensions required and not until immediately before installation of the ducts. The material from the excavation shall be placed where the least obstruction to vehicular and pedestrian traffic and the least interference with the surface drainage will occur, or as otherwise directed by the MOI/Engineer.

All the surplus excavated material shall be removed from the right-of-way and disposed of within 72 hours by the Sub-contractor/Contractor outside of the highway right-of-way in areas furnished by the Sub-contractor/Contractor, or as directed by the MOI/Engineer.

After the ducts are laid, the trench shall be filled to a depth of 150 mm with Class K140 concrete.

Backfilling shall be undertaken in accordance with Clause 605.14 of Section 6 (Stormwater Drainage) of these Specifications, and the trench and surrounding area shall be reinstated to a smooth condition acceptable to the MOI/Engineer.

The requirements of Section 17 (Utilities Structures) of these Specifications shall apply where relevant, except that Measurement and Payment shall be in accordance with Clause 1616 of these Specifications.

1614.02 UNDER NEW ROADWAYS

Where ducts are to be laid below roadways, which are being constructed under this Contract, this shall be done without re-excavation of completed new road construction.

1614.03 UNDER EXISTING TRAFFICKED ROADWAYS

The Sub-contractor shall not cut pavement, dig trenches or reinstate pavement during the hours 6 a.m. to 2 p.m. and 4 p.m. to 10 p.m. With the MOI's/Engineer's permission, the Sub-contractor may perform these works during the hours of 10 p.m. to 6 a.m. Saturday to Thursday, and all day Friday provided that all relevant permissions are obtained and provided that he complies with Section 18 (Maintenance and Protection of Traffic) and other relevant Clauses of these Specifications.

The Sub-contractor shall maintain cover on all trenches in the roadway in which work has not been completed during periods when no work is in progress. The covers shall be steel plates, strong enough to support traffic without undue deflection,, secured to the roadway with flat-head fasteners. Both plates and fasteners shall be subject to approval by the MOI/Engineer.

At the end of each day's work and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from that portion of the roadway open for use by vehicular and pedestrian traffic.

Where duct installation is required without cutting across the finished road surface, these ducts can be installed by "thrust boring" trenchless technology. However, this will depend on the actual soil and groundwater conditions on each specific site and their suitability for the application of such technique. Moreover, the Sub-contractor/Contractor is required to submit a detailed method statement for the trenchless duct installation to the MOI's/Engineer's approval. In this method statement, The Sub-contractor/Contractor shall provide the necessary qualifications of the equipment and staff involved in this operation and should demonstrate his ability and

sufficient experience for carrying out the thrust boring in these soil conditions without affecting the performance of the overlying pavement and without causing any permanent deformation or cracking to the pavement structure or to the various road furniture. The Sub-contractor/Contractor will also be held responsible for the repair and reinstatement of any defect in the road pavement and furniture that may result from the thrust boring to the original conditions, at his own expense

1614.04 UNDER EXISTING NON-TRAFFICKED ROADWAYS

The Sub-contractor may cut the existing pavement as required, without limitation on hours of working except as may be specified elsewhere in these Specifications.

1614.05 UNDER TILED FOOTWAYS

The requirements of Clause 1701.04 of Section 17 (Utilities Structures) of these Specifications shall apply.

1614.06 DUCT TERMINATIONS

Ducts terminating in pole or pedestal bases shall extend 100 mm above the foundation vertically and be preformed bends whose inside radius of curvature is at least six times the inside diameter of the ducts. The ends of all risers shall be provided with water-tight caps until wiring is started.

1614.07 SLOPE OF DUCT

Duct entering foundations, handholes and junction boxes shall enter from the direction of the run and shall be sloped to drain away from handholes or junction boxes where possible.

1614.08 TESTING OF DUCTS

After laying in the trench and couplings, all ducts shall be successfully rodded with a mandril, or other device having an outside diameter 80% of the inside diameter of the ducts. After the MOI/Engineer's approval, the trench shall be backfilled and the surface restored. The duct shall then be rodded once more and if the rodding is satisfactory to the MOI/Engineer, the duct section will be considered acceptable, subject to other applicable regulations. A rotproof polypropylene drawcord shall be left in all ducts in which cable is not installed. A 500 mm length of the cord shall be left coiled projecting beyond the end of the duct at each end.

All duct runs shall be free from moisture, rubbish and debris before cable is pulled.

1614.09 INSTALLATION OF UNDERGROUND STRUCTURES

Underground structures complying with the Clause 1606 of these Specifications shall be provided where shown on the Drawings. Additionally the Sub-contractor may, with the approval of the MOI/Engineer, install more underground structures to facilitate installation of duct and pulling of cable.

The requirements of Section 17 (Utilities Structures) of these Specifications shall apply, except that Measurement and Payment shall be in accordance with Clause 1616 of these Specifications.

1615 - INFORMATION, TESTING AND COMMISSIONING

1615.01 INFORMATION TO BE SUPPLIED BY THE SUB-CONTRACTOR

As soon as practicable the Sub-contractor shall submit to the MOI/Engineer the full detailed drawings, wiring schedules and any other information required under this Section 16 of the Specifications . Any modification required by the MOI/Engineer shall be incorporated without extra cost. Assembly of the equipment shall not take place until the final drawings have been approved by the MOI/Engineer. Any fabrication of equipment carried out prior to the MOI/Engineer approving the Final drawings shall be entirely at the Sub-contractor's risk and no claim will be entertained which results from abortive fabrication should the Drawings subsequently not be approved by the MOI/Engineer.

Prior to the issue of the Taking-Over Certificate, the Sub-contractor shall supply in triplicate and in the English language the following information and documents and unless these are handed over, a Taking-Over Certificate will not be issued :

a. Manufacturer's catalogues of the actual equipment installed for each and every item.
b. Instruction manuals for the installation, operation and maintenance of each and every type of equipment installed.
c. Priced parts lists clearly indicating the part number of each component used in the equipment, reference to which will enable the manufacturer to identify readily the exact component should also be provided.
d. One clear and legible copy of each as-fitted drawing of the completed traffic signal installation, showing exact routes of all cables, their number of cores and sizes and the location of all signals, on A1 size stable polyester film of 0.075 mm thickness, also three soft copies on a computer disk.
e. Any other information relating to the installation and which in the opinion of the MOI/Engineer is required for future maintenance of the system.

1615.02 TRAFFIC SIGNAL SETTINGS

The Sub-contractor shall establish suitable settings for the Controller intervals and variable facilities, where not previously defined in this Section. This shall include a requirement to, where appropriate, undertake calculations using the most recent version of the TRANSYT program developed by the Transport and Road Research Laboratory, UK or SYNCHRO developed by Trafficware Inc. USA, for all settings necessary to enable the Controller to operate in synchronisation with other Controllers installed under this Contract. The timing plans and time of day time-table shall be established from traffic data obtained from site surveys undertaken by the Sub-contractor and agreed with the MOI/Engineer prior to the commissioning of the signals and shall be reassessed no sooner than one month after all the signals have been commissioned.

The requirement to use TRANSYT or SYNCHRO may be waived at the discretion of the MOI/Engineer.

1615.03 TESTING

The Sub-contractor shall be responsible for the testing traffic control equipment.

1615.03.1 Factory Testing

Before shipment from the factory every Controller shall be tested to ensure reliable operation, and shall also be operated for a minimum period of one week under full lamp load.

1615.03.2 On-Site Testing

As soon as the work at any one installation is complete, the Sub-contractor shall notify the MOI/Engineer of his readiness to test and commission the system.

On-site testing shall be undertaken in the presence of the MOI/Engineer. Each Controller shall be operated in conjunction with a test or simulation board that will allow the Controller and all components in the cabinet to be tested under actual circuit loading conditions. The test facility shall have test switches and indicator lights to allow for the Controller to operate in all modes and the operator to verify the operations. At least two such test boards shall be provided and shall become the property of the Ministry of Public Works upon completion of the Contract. Normal operation, fault and safeguard conditions for all modes of operation of the Controller shall be thoroughly tested.

At Controllers of signalised intersections, a conflicting green signal shall be simulated to ensure the signal lamps are extinguished and flashing yellow started. If certain sequences are defined as illegal, a test of these conditions shall also be undertaken. Minimum and maximum greens and intergreen periods shall also be tested.

The design of the test board and the procedure for testing the Controllers shall be subject to the approval of the MOI/Engineer.

All minor faults shall be corrected prior to commissioning. If, however, the MOI/Engineer decides the equipment is not in accordance with the Contract, he may reject the equipment and he shall inform the Sub-contractor/Contractor of the reason in writing within a reasonable time.

1615.04 COMMISSIONING OF TRAFFIC SIGNALS

The Sub-contractor shall be responsible for commissioning the entire traffic signal.

After the equipment for each intersection has been fully and successfully tested, the Sub-contractor shall notify the MOI/Engineer of the date and time at which he intends to commission the equipment. Each installation shall be commissioned in the presence of the MOI/Engineer and the Sub-contractor shall demonstrate that the installation operates as required by the Specification. The equipment shall not be brought into service without the approval of the MOI/Engineer.

1616 - MEASUREMENT AND PAYMENT

1616.01 TRAFFIC SIGNAL

Measurement for traffic signals shall be by the Lump Sum for each system in accordance with the Drawings and Specifications or as directed by the MOI/Engineer. Payment for each required traffic signal shall be by the Lump Sum, which Lump Sum shall include full compensation for the supply and installation of the traffic signal materials; for the furnishing of all labour and material necessary for the installation of the traffic signal; for all testing, replacement of defective parts, any necessary corrective work, maintenance and guarantees; for all liaison with Kuwait Government Agencies that have traffic control and traffic signals responsibilities and for compliance with reasonable requirements of these agencies; and for other incidental works specified or required including minor design revisions that are or become necessary to properly complete the work.

Measurement and payment for revised quantities of trench and backfill, cable ducts and cables necessitated by minor design revision shall be in accordance with Clauses 1402.04 and 1702.08 of Sections 14 and 17 of these Specifications and shall be an addition or deduction as appropriate. Payment shall be made under this Section 16 of the Bills of Quantities.

1616.02 TRAFFIC SURVEILLANCE DUCTS

Measurement and payment shall be in accordance with Clause 1702.08 of Section 17 (Utilities Structures) of these Specifications and payment shall be made under this Section 16 of the Bills of Quantities.

Measurement for a traffic surveillance duct crossing at an underbridge median shall be by the linear metre of each duct pipe. Payment shall be at the rate inserted in Section 16 of the Bills of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including but not limited to supplying and fixing support brackets and PVCu pipes, all necessary jointing accessories, fittings, cutting of pipes, waste allowance, testing and any temporary staging.

1616.03 ITEMS IN THE BILL OF QUANTITIES

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1616.1	Traffic signals	L.S
1616.2	Duct Crossing at underbridge median	m

1617 - OVER-HEIGHT VEHICLE DETECTION SYSTEM

1617.01 DESCRIPTION

The system is to detect over-height vehicle/trucks approaching underpass and displaying an announcement message to alert drivers not to enter the underpass. The system shall include an alarm system announcement along with the ability for disabling this facility based on user’s requirements. Detectors and warning items are to comply with local regulations.

The works shall consist of the supply, installation and putting into satisfactory service of the overheight vehicle detection system complete with transmitter unit, receiver unit, warning signs, mounting poles, ducting, drawpits, excavation and similar civil works, cabling, connection and all necessary services for the complete installation.

1617.02 MATERIALS

Materials employed shall be the latest technology and best of their respective kind and modern practice, selected and treated so that no corrosion will occur during the lifetime of the installation estimated at 20 years.

The equipment shall be designed to operate on A.C. 240 volts single phase 50 Hz with a voltage variation of plus 15 percent or minus 20 percent and frequency variation of plus or minus four percent. If the equipment is sensitive to voltage fluctuations within the above stated limits, an automatic voltage stabilizer shall be incorporated in the system, along with a stand by uninterruptible power supply system for maintaining system memory.

Electronic equipment shall use components of assessed quality in accordance with the system outlined in BS 9000-3 General Requirements for a System for Electronic Components of Assessed Quality or other approved equal.

All equipment shall be designed and derated for continuous operation under operating conditions stipulated in Clause 1601.01 of these Specifications. The variation in light intensity caused by the shadow of passing clouds shall not interfere with the proper operation of the equipment. The equipment shall be suitable for uninterrupted full load operation exposed to sun, dust storms, corrosive elements and the adverse climatic conditions at the location.

All wiring shall be neatly and securely fixed in position in an approved manner. The wiring shall be in high temperature PVC insulated cables or silicon rubber, colour coded for ease of identification. All terminals shall be of adequate size.

All equipment shall have a proven 'in service' record. Documentary evidence of this shall be submitted. Full environmental test should be carried out on a production sample by an Independent Testing Authority and a certificate supplied to show the suitability of the equipment for use in the specified environment.

Safety Features: NEMA 3R (IP 66 of IEC 60529) rated metallic equipment enclosures shall be provided with terminals for attachment of ground safety circuit.

Signs shall be mounted on straight by-brackets supporting both top and bottom of the sign.

Attachment shall be of stainless steel clamps and mounting brackets which shall incorporate a wiring duet for the sign wiring. The attachment shall allow vertical and angular adjustment of the sign assembly and shall be suitable for the sign presentation.

Masts shall be designed and constructed to provide adequate support and stability for the sign and shall be suitable to support more than one assembly.

Masts shall be constructed from seamless steel, tubular, with a wall thickness not less than 4.5mm and a tensile strength of 520 MN/sq.m hot dipped galvanized. No machining operation shall be allowed after completion of the galvanizing process. Masts shall be painted with 2 coats of epoxy resin paint to an approved color finish after completion of the galvanizing process as required by the MOI/ Engineer.

Masts shall be complete with base compartment and pole top compartment complete with terminal chambers for connecting incoming cables.

Mounting heights of sign centres, the type of sign and the signal presentation shall be as will be detailed by the MOI/Engineer.

1617.03 OPERATION REQUIREMENTS

All overheight vehicles or vehicle loads traveling toward the tunnel shall be detected and a warning sign shall be given. Vehicles traveling away from the tunnel shall be ignored by the detection equipment. Detection of vehicles traveling toward the tunnel shall be counted and recorded on an installed electronic counting device.

The detection system shall consist of visible red or infra red source(s) and spectrally matching detector(s) mounted on poles positioned on opposite sides of the approach roadway. The alignment and height of the visible red or infra red beam shall be preset to identify vehicles over 4.25m above the roadway at the line of detection or as requested by theMOI/Engineer.

Positive action shall be taken to attract the attention of the driver to the fact that he specifically will have an accident if he proceeds. The action must cause him to become alert to the extent that he reacts as instructed. Caution should be taken to cause the least possible disturbance to other motorists and to minimize the adverse effects of increased ambient sound or light in the area.

Warning and instructions for drivers overheight vehicles shall be stated on the face of the warning sign which shall be illuminated internally, i.e., nature of danger "OVERHEIGHT" and action to be taken ("STOP" or "TURN RIGHT" or "EXIT RIGHT" or "USE RIGHT (LEFT) LANE," or "DO NOT ENTER" etc) if the driver proceeds. The action must cause the driver to become alert to the extent that he should react as instructed. The wording shall be in both Arabic and English.

Warning Sub-system shall consist of a flashing light, an audible alarm, and an electronic message board.

Upon receiving the control signal from the detection sub-system, this warning sub-system is to be activated and shall respond by alerting the driver to either stop the vehicle or take an alternative route. The warning sub-system shall comprise the following:

i. Warning message on LED display

ii. Loud audible alarm, 111 dB@ 3m

iii. Flashing Red warning light

1617.04 PHYSICAL REQUIREMENTS

The detector unit shall be solid state with printed circuit boards and regulated power supply. The unit shall be of modular construction. It shall have an effective range of 3m to 38m with a reaction speed range of 1.6 km/h to120 km/h for a 50 mm diameter object 25 mm above the detection height. It shall provide a fault reporting output upon loss of space/detector power or total failure.

Sensors are to have NEMA 6P rated enclosures, direction selection to be from a selection switch. No tools or adjustment is required.

Four LEDs and meter shall be provided for ease of alignment and testing. Provision shall be made for the elimination of the effect of ambient light and an internal environmental control element that reduces operational failure from fog, condensation and insects. Dimensions shall not exceed a maximum overall size of 460 x 380 x 250 mm. The housing shall be of high grade extruded aluminum and sheet aluminum of not less than 3.2 mm thickness, and weather sealed for rugged durability and extended life. The mounting shall allow for directional adjustment and aiming after initial installation.

Two 3.2 mm) boresight holes are to be located at Top-Middle of each housing. Front and rear screws are to be installed in these holes so as to insure a weather tight enclosure, and should be removed to allow alignment of units. Looking through boresight hole from rear of unit so as to see through the boresight hole in front of unit gives the installer a basic means of aiming the unit in the proper direction. Focusing the unit on opposite sides of the road in the center of the front boresight while looking through the rear boresight hole ensures that a general alignment is accomplished. This step should be done from both Transmitter and Receiver Unit locations. Fine tuning of alignment can then be done electronically.

The transmitter unit and the receiver units shall each be provided with a barrier to protect the operating equipment. The enclosure shall maintain its structural integrity for the operational life of the equipment and shall allow ready access for control adjustment and electrical interconnection without the use of any tools except a Phillips head screwdriver.

Each of the equipment units shall be provided with means for rigidly attaching the unit to a vertical cylindrical pole without requiring any machining operation. The attachment means shall not stress or deform the unit and shall prevent the movement of the unit in any direction by the force developed by wind. The mounting means shall allow adjustment of the vertical position on the pole. The mounting means for the transmitter unit and the receiver unit shall have the capability of adjusting the angular orientation of the optical axis in both the horizontal and vertical plane over an angular range of plus or minus five degrees from horizontal. The transmitter and receiver unit shall be mounted to detect the presence of vehicles that exceed the specified vertical height.

Warning Sign shall meet all electrical /electronic specifications and shall conform, in all essential elements, with the provisions of the U.S. D.O.T, F.H.A. Manual on Uniform Traffic Control Devices. Plastics on sign faces

shall be protected by LEXAN or other material providing equal or greater defense against flying object damage or vandalism. Signs shall be activated and time controlled by the Detection unit. Lighting shall be provided by high output fluorescent bulbs for message and incandescent bulbs with parabolic reflectors for arrows at the top and bottom of sign. Flashers on LED signs should be of 300 mm diameter.

Sign Housing shall be as indicated on Drawings and provided with rectangular (shape) reinforced aluminum capable of withstanding wind loading up 95 km/h and provided with a sun shield projecting at least 360 mm. Letters and arrows shall be normally blanked out. When illuminated, arrows shall be red in color, but can be made in any color specified (IP 65 rating).

Unit Mounting Poles (shaft) shall be one or two piece, adjustable height, seamless, round aluminum tube. Poles shall include a handhole centered 460 mm above the bottom of the shaft. A cover, with stainless steel attachment screws, shall be provided for the handhole.

Base Flange for the attachment of the shaft to the foundation shall be a one piece cast socket of aluminum alloy. Concrete footing and four anchor bolts shall be provided specifically designed to accommodate the overheight detector, signs, etc. specified herein. Poles come in two styles: 3m non adjusting or 3 - 5 m adjusting (there shall be two pieces or shafts with this pole).

Single core cables for internal wiring shall be 450/750 volt flexible PVC insulated copper in accordance with BS 6004-2000 or approved equal standard with high temperature insulation where operating in high ambient temperature conditions. The conductor size shall be in accordance with the circuit requirements. Cables shall be bunched, clipped and properly secured to form a complete wiring loop.

Power and signal cabling shall be provided between the receiver unit electronics and the junction box adjacent to the mounting pole foundation. Power for the receiver and transmitter units will be made available at the junction box located adjacent to the mounting pole foundation.

Standby Power: A solar panel shall be supplied with the OVDS to make use of solar energy. This is recommended to enable the system to remain powered even under power failure conditions for limited periods.

Fault Reporting: A fault reporting function would be incorporated in the system to detect any malfunctions in the system and alert the concerned authorities.

All non current carrying parts of the equipment and installation shall be earthed.

The armoring and screens of all multi-core cables installed directly in the ground shall be bonded and connected to the earth bar together with the earth core of the electricity supply cable. A separate single core copper PVC insulated (green/yellow) installed back to the electricity supply point shall be provided if the incoming cable does not include the earth.

1617.05 CONSTRUCTION REQUIREMENTS

The Sub-contractor/Contractor shall supply and install the underground ducts, construct the cable drawpits indicated on the Drawings or as required on site for installation of the cables.

The Sub-contractor/Contractor shall be responsible for all excavation, draining trenches, forming of duct assembly, backfilling, and removal of excess earth and restoring finished grade to its original condition.

Where duct installation is required without cutting across the finished road surface, these ducts can be installed by “thrust boring” trenchless technology. However, this will depend on the actual soil and groundwater conditions on each specific site and their suitability for the application of such technique. Moreover, the Sub-contractor/Contractor is required to submit a detailed method statement for the trenchless duct installation to the MOI/Engineer’s approval. In this method statement, he shall provide the necessary qualifications of the equipment and staff involved in this operation and should demonstrate his ability and sufficient experience for carrying out the thrust boring in these soil conditions without affecting the performance of the overlying pavement and without causing any permanent deformation or cracking to the pavement structure or to the various road furniture. He will also be held responsible for the repair and reinstatement of any defect in the road pavement and furniture that may result from the thrust boring to the original conditions, at his own expense.

Ducts shall be as specified under Clause 1402.03 of Section 14 (Lighting and Electrical Works) of these Specifications.

Ducts shall be laid within a trench in close cluster formation.

Concrete foundations may be pre-cast or cast in-situ as detailed on the Drawings or as instructed by the MOI/Engineer.

Excavations for construction of the foundations shall be in soil of any nature, including rock or demolition of old structures. Where the foundations are located in a backfill, the backfill shall be properly compacted at the time and before the excavation is carried out. Cases in doubt shall be reported to the MOI/Engineer.

The excavated hole for the foundation shall be well cleaned and its sides compacted and the base and sides of the excavation shall be lined with a heavy duty sheet bitumen or polythene waterproof membrane before work on the foundation properly commences.

Where pre-cast foundations are to be installed they shall be inserted in the excavation supported at the correct level and “grouted” in. In-situ foundations shall be constructed as shown on the Drawings with the concrete poured around the reinforcing and holding down bolts and consolidated in one operation.

Concrete and reinforcement shall conform to the requirements of Section 5 (Concrete Works) of these Specifications

The position of the anchor bolts and the level of the top surface shall be exactly determined and adjusted. PVC ducts of sizes shown on the Drawings shall be installed in the foundation for cable access.

The tops of the foundation blocks shall be horizontal and level as detailed on the Drawings; any other exceeding plus or minus 25mm shall be corrected.

The design of the Civil Works shall take into consideration foundation soil conditions and shall be approved by the MOI/Engineer.

1617.06 MEASUREMENT AND PAYMENT

1617.06.1 Method of Measurement and Basis of Payment

Overheight vehicle detection system shall be measured as the number of completed systems comprising: transmitter and receiver units, warning signs, masts with interconnecting cables and earthing as necessary, supplied, erected and put into operation in accordance with the Specification, including all foundations, ducts, drawpits and associated civil works.

The quantity of completed and accepted work measured as provided for above will be paid for at the unit rate for a complete operational system of overheight vehicle detection and warning system in the Bills of Quantities which rate shall be full compensation for supplying, installing, testing and putting into service, and for materials, labor, equipment, tools, supplies and other work items necessary for the proper support and completion of the work as specified above and in the Conditions of Contract.

1617.06.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1617.1	Overheight vehicle detection and warning system (system complete) (location shown on Drawings)	nr

1618 - RAMP METERING

1618.01 DESCRIPTION

Design of ramp metering projects shall conform to the "Ramp Meter Design Manual" prepared by the Traffic Operations Program of the California Department of Transportation (CALTRANS).

Geometric ramp design for new facilities should normally be based upon the projected peak-hour traffic volumes 20 years after completion of construction, except as stated in the Highway Design Manual (HDM) Index 103.2.

Geometric ramp design for operational improvement projects (including ramp meters) should be based on current peak-hour traffic volume (this is considered to be data that is less than two years old). If this data is not available it should be obtained before proceeding with design.

The design advice and typical designs that follow should not be directly applied to ramp meter installation

projects, especially retrofit designs, without giving consideration to "customizing" the geometric design features to meet site and traffic conditions (i.e. design highway volume, geometry, speeds, etc.). Every effort should be made by the designer to exceed the recommended minimum standards provided herein, where conditions are not restrictive.

1618.02 METERED SINGLE-LANE ENTRANCE RAMPS

Geometrics for a single-lane ramp meter should be provided for volumes up to 900 vehicles per hour (vph). Where truck volumes (3-axle or more) are 5% or greater on ascending entrance ramps to freeways with sustained upgrades exceeding 3% (i.e. at least throughout the merge area), a minimum 150 m length of auxiliary lane should be provided beyond the ramp convergence point (A guide for determining the additional length of acceleration lane needed for grades is in Exhibit 10-71 of "A Policy on Geometric Design of Highways and Streets, 2004" by AASHTO).

A multi-lane ramp segment may be provided to increase vehicle storage within the available ramp length (see Clause1618.05, Storage Length) of these Specifications and/or to create a preferential lane for HOVs.

1618.03 METERED MULTI-LANE ENTRANCE RAMPS

When entrance ramp volumes exceed 900 vph, and/ or when an HOV lane is determined to be necessary, a two or three lane ramp segment should be provided.

On two-lane loop ramps, normally only the right lane needs to be widened to accommodate design vehicle off-tracking.

Three-lane metered ramps are typically needed to serve peak (i.e. commute) hour traffic along urban and suburban freeway corridors.

The adverse effects of bus and truck traffic on the operation of these ramps (i.e. off-tracking, sight restriction, acceleration of characteristics on upgrades, etc.) is minimized when the ramp alignment is tangential or consists of curve radii not less the 90 m. The recommended widths for metered ramps are:

		Pavement Widths	
Metered	Traveled	Shoulder	
Ramp	Way*	Inside	Outside
1-lane	3.6 m	1.2 m	2.4 m
2-lane	7.2 m	1.2 m	2.4 m
3-lane	10.8 m	0.6 m	0.6 m

*See the Highway Design Manual, Index 504.3, for providing additional ramp width for radii 90 m or less.

On local street entrance ramps, the multi-lane segment should transition to a single lane width between the ramp meter limit line and the 2 m separation point (from the mainline edge of traveled way). The lane drop transition should be accomplished with a taper of 50:1 unless a lesser taper is warranted by Site and/or Project specific conditions which control the ramp geometry and/or anticipated maximum speed of ramp traffic. For example, "loop" entrance ramps would normally not allow traffic to attain speeds which would warrant a 50:1 lane drop taper.

Also, in retrofit situations, existing physical, environmental or Right of Way constraints may make it impractical to provide a 50:1 taper, especially if the maximum anticipated approach speed will be less than 80 km/h. Therefore, depending on approach geometrics and speed, the lane drop transition should be accomplished with a taper of between 30 and 50:1. However, the lane drop taper past the limit line shall not be less than 15 to 1.

Where truck volumes (3-axle or more) are 5% or greater on ascending entrance ramps to freeways with sustained upgrades exceeding 3% (i.e. at least throughout the merge area), a minimum 300 m length of auxiliary lane

should be provided beyond the ramp convergence point (A guide for determining the additional length of acceleration lane needed for grades is in Exhibit 10-71 of "A Policy on Geometric Design of Highways and Streets, 2004" By AASHTO)..

When ramp volumes exceed 1,500 vph, a 300 m minimum length of auxiliary lane should be provided beyond the ramp convergence point. If an auxiliary lane is included, the ramp lane transition may be extended to the convergence point. However, the proximity of the nearest interchange may warrant weaving analysis before the ramp lane transition is extended beyond the 2 m separation point. A longer auxiliary lane should be considered where mainline/ramp gradients and truck volumes warrant additional length.

1618.04 METERED FREEWAY-TO-FREEWAY CONNECTORS

Freeway-to-freeway connectors may also be metered when warranted. The need to meter a freeway to- freeway connector should be determined on an individual basis. Because connector ramps provide a link between two high speed facilities, drivers do not expect to stop, nor do they expect to approach a stopped vehicle.

The installation of ramp meters on connector ramps shall be limited to those facilities which meet or exceed the following geometric design criteria:

standard lane and shoulder widths

"tail light" sight distance, measured from 1070 mm eye height to a 600 mm object height, is provided for a design speed of 80 km/h minimum

All lane drop transitions on connectors shall be accomplished with a taper of 50:1 minimum

1618.05 STORAGE LENGTH

In keeping the Strategic Plan to maximize the effectiveness of operational strategies, an important design consideration for a ramp meter system is providing adequate storage for queues. The Ministry of Interior Operations Branch responsible for ramp metering shall be consulted to determine the desirable ramp meter storage.

Ramp meters have practical lower and upper output limits of 240 and 900 vph per lane, respectively. Ramp meter signals set for flow rates outside this range tend to have high violation rates and cannot effectively control traffic. Therefore, on a ramp with peak hour volume between 500 and 900, a two-lane ramp meter may be provided to double the vehicles stored within the available storage area. A single-lane ramp meter should be used when rates are below 500 vph and no HOV preferential lane is provided.

To minimize the impact on local street operation, every effort should be made to meet the recommended storage length. Wherever feasible, ramp metering storage should be contained on the ramp by either widening or lengthening it. Improvements to the local street system in the vicinity of the ramp should also be thoroughly investigated where there is insufficient storage length on the ramp and the ramp queue will adversely affect local street operation. The storage length that can be provided on the ramp may be limited by the weaving distance to the next off-ramp and available right of way. These improvements can include widening or restriping the street(s) or intersection(s) to provide additional storage or capacity. Signal timing revisions along the corridor feeding the ramp can also enhance the storage capability. These will require coordination with the local agency consistent with the regional traffic operations strategy. Ultimately system-wide adaptive ramp metering will coordinate with local street and arterial signal systems.

The current peak period 5, 6, or 15 minute arrival rates and anticipated or current ramp meter discharge

rates should be used to determine the storage length required for ramp metering. It is recommended that a minimum vehicle spacing of 9 m be used for designing storage on metered ramps. Additional spacing should be provided for locations where there are significant percentages of trucks, buses, or recreational vehicles.

It is the responsibility of the Operator to mitigate the effect of ramp metering, for initial as well as future operational impacts, on local streets that intersect and feed entrance ramps to the freeway.

1618.06 STRUCTURAL SECTION

In planning for the possibility of future widening, the structural section for the ramp shoulders should be equal to the ramp traveled way structural section. In locations where failure of loop detectors due to asphalt concrete

pavement deterioration is a concern, a Portland Cement Concrete (PCC) pad may be considered on new construction and rehabilitation projects. The concrete pad should cover the metering detector loop area upstream and downstream of the limit line.

1618.07 METER LOCATION

On single-lane ramps, the ramp meter signal standard should be placed on the driver's left, (See Clause 1618.11 of these Specifications).

1618.08 LIMIT LINE LOCATION

The limit line location will be determined by the selected transition taper, but should be a minimum of 23 m upstream of the 7 m point on the entrance ramp. A single 300 mm solid white line shall be placed across all metered lanes. Staggered limit lines shall not be used.

1618.09 HIGH OCCUPANCY VEHICLE (HOV) PREFERENTIAL LANE

Ramp meter installations should operate in conjunction with, and complement other transportation management system elements and transportation modes. As such, ramp meter installations should include preferential treatment of carpools and transit riders. Specific treatment(s) must be tailored to the unique conditions at each ramp location, however the standard or base treatment upon which other strategies are designed is the High Occupancy Vehicle (HOV) preferential lane.

An HOV preferential lane shall be provided at all ramp meter locations. In general, the vehicle occupancy requirement for ramp meter HOV preferential lanes will be two or more persons per vehicle. At some locations, a higher vehicle occupancy requirement may be necessary. The occupancy should be based on the HOV demand and coordination with other HOV facilities in the vicinity.

A preferential lane should typically be placed on the left, however demand and operational characteristics at the ramp entrance may dictate otherwise. The Ministry of Interior Operations Branch responsible for ramp metering shall determine which side of the ramp they shall be placed, and whether or not the HOV lane will be metered.

Access to the HOV preferential lane may be provided in a variety of ways depending on interchange type and the adequacy of storage provided for queued vehicles. Where queued vehicles are expected to block access to the HOV preferential lane, direct or separate access should be considered. Designs should consider pedestrian/bicycle volumes, especially when the entrance ramp is located near a school or the local highway facility includes a designated bicycle lane or route. Contact the Ministry of Interior Operations Branch responsible for ramp metering to discuss the application of specific design and/or general issues related to the design of HOV preferential lane access.

Signing for an HOV preferential lane should be placed to clearly indicate which lane is designated for HOVs. Real-time signing at the ramp entrance, such as an overhead extinguishable message sign, may be necessary at some locations if pavement delineation and normal signing do not provide drivers with adequate lane usage information. To avoid trapping Single Occupancy Vehicles (SOVs) in an HOV preferential lane, pavement delineation at the ramp entrance should lead drivers into the SOV lane.

1618.10 ENFORCEMENT AREAS AND MAINTENANCE PULLOUTS

Enforcement areas should be provided on all two-lane and three-lane ramps with HOV lanes.

On single- lane ramps, a paved enforcement area is not necessary but the area should be graded to facilitate future ramp widening. Enforcement areas are used by the Highway Patrol to enforce vehicle occupancy

requirements. At locations where the HOV lane is metered, the enforcement area should begin as close to the limit line as practical. Where unmetered, it should begin approximately 50 m downstream of the limit line. On three-lane ramps, the enforcement area should be downstream of the mast arm standard, approximately 21 m from the limit line. The length of the enforcement area and its distance downstream of the limit line may be adjusted to fit conditions at the ramp with Highway Patrol approval.

The Ministry of Interior Operations Branch responsible for ramp metering shall coordinate enforcement issues with

the Highway Patrol. The Highway Patrol shall be contacted during the Project Report stage, prior to design, to discuss any variations needed to the enforcement area design. A paved pullout area near the Controller cabinet should be provided for safe and convenient access for Maintenance and Operations personnel . If a pullout cannot be provided, a paved or "all weather" walkway should be provided to the Controller cabinet.

1618.11 RAMP METERING HARDWARE

The minimum ramp metering equipment that should be installed at each entrance ramp is described below. Some locations may require additional equipment. The Ministry of Interior Operations Branch responsible for ramp metering shall be consulted to determine if any additional equipment is required and should review all signal, Controller, loop detector, and advance warning devices.

1618.11.1 Signal Heads and Standards

1618.11.1.1 One- and Two-Lane Ramps

Install upper three-section (300 mm red, yellow and green lenses) and lower two- or three-section heads (200mm lenses) on a Type 1 standard. A two section lower head should be used for "one car per green" output and a three section lower head for "two cars per green" output. A one-section head with a 200mm red lens (signal status indicator) should be installed on the backside of Type 1 standards for enforcement. For a one-lane ramp, install standard on the left side of ramp. At 2-lane ramps, a Type 1 standard and signal heads should be installed on each side of the ramp. No signal standard is needed for non-metered HOV lanes. Standards should be approximately 1 m from the edge of shoulder and 300 mm downstream of the limit line. On ramps with minimal shoulders and flat slopes, standards should be placed in locations that reduce knock-downs.

Some locations may need a special wall-mount design or a mast arm for situations where the wall restricts the room for a normal Type 1 standard. Lighting standards, such as Type 15, may be used to illuminate the limit line during pre-dawn or evening conditions.

1618.11.1.2 Three-Lane Ramps

Install three, three section heads (two.three section heads, if HOV lane is not metered) on mast arm standard located on the right side of the ramp approximately 21 m downstream of the limit line. Type 26 or Type 27 with wind velocity of 129 km/hr is recommended. Programmed visibility (PV) heads should be used to limit visibility from mainline traffic. However, freeway connectors with limited sight distance or high speed approach traffic may require the use of standard heads for better visibility. Guardrail or barrier should be considered where mast arm installation is less than 9 meters from traveled way.

Also install upper (300 mm red, yellow and green lenses) and lower (200 mm lenses) heads on Type 1 standards on each side of the ramp. The signal status indicator should be included.

1618.11.2 Detector Loops

Consult current CALTRANS Standard Plans ES-5A and 5B for detector types and installation, sawcut, slot and winding details. Loop configuration should be Type A or Type E and centered in the lane. Type Q loops may be used for demand loops (loops placed upstream of the limit line to detect approaching vehicles) and passage loops (loops placed downstream of the limit line to detect passing vehicles) on entrance ramps.

1618.11.2.1 Mainline Loops

Two loops per lane should be installed on the mainline. Spacing shall be 6.1 m from leading edge to leading edge. Contact the Ministry of Interior Operations Branch responsible for ramp metering to determine location of mainline loops. In general, the mainline loops should be located upstream of the entrance ramp nose, opposite the limit line. Location of the detectors should be adjusted to avoid transverse pavement joints or structures.

1618.11.2.2 Entrance Ramp Loops

Ramp loops (demand and passage) should be installed for each entrance lane near the limit line. An oversized loop may be considered where the lane width is greater than 3.6 m, such as for loop on ramps.

The number and spacing of ramp loops should be determined by the Ministry of Interior Operations Branch responsible for ramp metering. Typical quantities for demand loops are 2, 3, and 4. Consult with the Ministry of

Interior Operations Branch for the location of an additional count loop downstream. An oversized loop may be needed to increase accuracy of counts. Concrete pads may be used to help prevent loop failure,

1618.11.2.3 Exit Ramp Loops

One loop per exit ramp lane should be installed for count information and loop calibration. The Ministry of Interior Operations Branch responsible for ramp metering should be consulted to determine the location of the loops.

1618.11.2.4 Queue Loops

One loop per entrance ramp lane should be installed for queue detection near the connection of the surface street.

1618.11.3 Controller Assembly

One Controller Cabinet should generally be installed for each entrance ramp. In some cases three lanes can be accommodated by one Controller. Exact number and location of Controller cabinets will be determined by the Ministry of Interior Operations Branch responsible for ramp metering. In general, the cabinet should be located to minimize the possibility of being hit by an errant vehicle and to allow safe and convenient access by Maintenance and Operations personnel. If possible, it should be located where the signal faces can be observed. Refer to the California Department of Transportation Traffic Manual Chapter 9 and Standard Plans for location and installation details. If the cabinet is not located in an easily accessible location, a paved access area should be provided.

Cabinets should include a Model 170 or Model 2070 Controller, an input file with sensor units, an output file with load switches, a power distribution assembly, and a modem.

Electrical Service shall be provided for each Controller/cabinet assembly.

1618.11.4 Communications

Install one telephone demarcation cabinet per telephone service point. Ministry of Interior Operations Branch responsible for ramp metering, in coordination with the telephone company, will determine the telephone requirements and the exact location. If more than one entrance ramp is to be metered, a telephone bridge should be installed in the telephone demarcation cabinet or in the Controller cabinet which is nearest to the telephone demarcation cabinet.

At locations where telephone service is not available or too costly, new communication technologies such as fiber-optic, microwave, or radiowaves may be proposed.

1618.11.5 Advance Warning

In general, an advance warning device should be installed at ramps where sight distance to the ramp meter signal or queue is impaired.

It is recommended that advance warning be placed at all locations to indicate that metering is operational. It should be installed near the ramp entrance facing each direction of traffic entering the ramp. It should also be visible to surface street traffic before entering the ramp.

A flashing beacon with "Signal Ahead" sign mounted beneath it may be used or an internally illuminated "METER ON" sign. The flashing beacon or "METER ON" sign should be activated during metering operation. Additional flashing beacons should be provided on long ramps where signals cannot be seen on the approach. The type of warning device should be determined by the Ministry of Interior Operations Branch responsible for ramp metering.

On freeway-to-freeway connectors, high visibility extinguishable message signs (EMS) should be installed for advance warning.

On connectors, a sequence of two signs should be used. The "METER ON" sign should be installed at least 30 m downstream from the 7 m point of the exit gore area. The "PREPARE TO STOP" sign should be installed 120 m to 180 m downstream of the "METER ON" sign and at least 300 m upstream of the limit line. If the queue extends upstream of the "PREPARE TO STOP" sign, its location should be adjusted or an additional sign installed upstream of the end of queue.

On local street ramps with high approach speeds, the same installation as connectors should be used if possible. However, the length of local street ramps may require the sign spacing to be reduced. The minimum distance between the "PREPARE TO STOP" sign and the limit line should be the maximum queue length sustained for at least 15 minutes plus the stopping sight distance for the approach speed. The minimum distance between the "METER ON" sign and the "PREPARE TO STOP" sign should be 90 m. Consult the Ministry of Interior Operations Branch responsible for ramp metering for exact placement.

The EMSs may be installed overhead or ground-mounted. If ground-mounted on a multi-lane connector ramp, a sign on each side of the connector should be installed for each message. Additional EMSs may be placed in advance on the mainline to indicate that the connector meter is on. Power for the EMSs should be sourced out of the designated load switches in the Controller cabinet.

1618.12 SIGNING AND PAVEMENT MARKINGS

1618.12.1 Signing and Striping Typicals

All signs and markings shall conform to current Kuwait Manual on Uniform Traffic Control Devices. Exceptions should be reviewed by the Ministry of Interior Operations Branch responsible for ramp metering, See Clause1618.08 of these Specifications for limit line placement.

1618.12.2 Vehicles Per Green

Where a Type 1 standard is used, place a sign under the lower signal head, indicating the number of vehicles allowed for each green. Where a mast arm is used, place a sign indicating the number of vehicles allowed for each green to the right of each signal head. The sign can read as one of the following:

ONE CAR PER GREEN.

ONE CAR PER GREEN EACH LANE.

ONE CAR PER GREEN THIS LANE.

An alternate message indicates "2" cars per green.

1618.12.3 HOV Signing and Markings

The standard signing for an HOV preferential lane should be placed to clearly indicate which lane is designated for HOVs. The standard HOV lane pavement marking shall be an elongated diamond. Markings should be placed adjacent to HOV signs. The pavement legend "CAR POOL LANE" may be painted between the diamond symbols on new projects to supplement, but not substitute for, the standard HOV lane markings. These legend markings, after their initial application, should not be maintained. An additional set of signs and pavement markings should be placed on long ramps. A sign posted with the times indicated or a "WHEN METERED" indication allows SOVs in the lane during non-metering hours. A sign posted without the times, prohibits SOVs from using the HOV lane at all times.

1618.13 MEASUREMENT AND PAYMENT

1618.13.1 Method of Measurement and Basis of Payment

Measurement for ramp metering shall be by the Lump Sum for each system in accordance with the Drawings and Specifications or as directed by the MOI/Engineer. Payment for each required ramp metering shall be by the Lump Sum, which Lump Sum shall include full compensation for the supply and installation of the ramp metering materials; for the furnishing of all labour and material necessary for the installation of the ramp metering; for all testing, replacement of defective parts, any necessary corrective work, maintenance and guarantees; for all liaison with Kuwait Government Agencies that have traffic control and traffic signals responsibilities and for compliance with reasonable requirements of these agencies; and for other incidental works specified or required including minor design revisions that are or become necessary to properly complete the work.

Measurement and payment for revised quantities of trench and backfill, cable ducts and cables necessitated by minor design revision shall be in accordance with Clauses 1402.04 and 1702.08 of Sections 14 and 17 of these Specifications and shall be an addition or deduction as appropriate. Payment shall be made under this Section 16 of the Bills of Quantities.

1618.13.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1618.1	Ramp Metering (per system)	L.S

SECTION 17: UTILITIES STRUCTURES

1700 - GENERAL

1700.01 SCOPE

This Section describes the requirements for the construction of Utility Structures as detailed on the Drawings. The Utility Structures shall include reinforced concrete culverts for water, gas, oil and sewage mains, manholes, handholes and direct buried and concrete encased ducts etc. all to dimensions and in the locations shown on the Drawings.

The Contractor shall refer to and comply with the current Regulations and Specifications of the Utilities Ministries, Authorities and Companies concerning construction that will eventually be used by these bodies or any work adjacent to their equipment, plant, cables, pipes etc. This requirement will not relieve the Contractor of any responsibility for taking every precaution to avoid damage to equipment, plant, cables, pipes etc. and he will be held responsible for all costs in connection with such damage in accordance with Section 1 (General) of these Specifications. Payment for complying with the Utilities Ministries, Authorities' and Companies' Regulations and Specifications will be deemed to have been included in the rates for works included in the Bills of Quantities.

The Regulations and Specifications of the Utilities Ministries, Authorities and Companies shall take precedence over this Section 17 where there is conflict or ambiguity.

Where crossings are installed under existing highways it will be necessary to remove and reinstate, either temporarily or permanently as shown on the Drawings, noted in these Specifications or as directed by the Engineer, existing asphaltic pavement courses, kerbing, sidewalks, road signs and all other street furniture.

1700.02 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

D 1751 Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-Extruding and Resilient Bituminous Types)

AASHTO

T 180 Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54 kg (10-lb) Rammer and a 457 mm (18 in) Drop.

BS (BRITISH STANDARD)

BS EN 124 Gully tops and manhole tops for vehicular and pedestrian areas

BS EN ISO 1461 Hot dip galvanized coatings on fabricated iron and steel articles

BS EN 1496 Fixed ladders for manholes

BS EN 1917 Concrete manholes and inspection chambers, unreinforced, steel fibre and reinforced

BS 3416 Black bitumen coating solutions for cold application

BS 4211 Specification for permanently fixed ladders

BS 5911-3 Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete manholes and soak ways

BS EN 13101 Manhole step irons (malleable cast iron)

1701 - REMOVAL AND REINSTATEMENT OF EXISTING ROADS

1701.01 GENERAL

This work shall comprise the removal of asphaltic and non-asphaltic roadway pavement courses, kerbs, paving slabs and/or asphaltic or non-asphaltic pavement courses on sidewalks and medians etc., affected street furniture, and the replacement of the same or new on completion of construction and backfilling of the Utilities Structures.

1701.02 REMOVAL AND REPLACEMENT OF PAVEMENT COURSES

1701.02.1 Asphaltic Pavement Courses

a. Removal of Pavement Courses – Asphaltic concrete pavement courses shall be broken out with pneumatic asphalt-cutting tools to the extent required and shall be removed, cleaned of all deleterious substances and stockpiled in areas designated by the Engineer within 60 km of the source.

b. Materials for Pavement Replacement – The materials required for the replacement of asphalt pavement courses shall be as specified in Section 3 (Sub-Base and Base Courses) and Section 4 (Asphalt Works) of these Specifications.

c. Equipment for Pavement Replacement – The Contractor shall be responsible for supplying all the equipment and labour necessary to perform the required work described herein and as directed by the Engineer. The major items of equipment for asphaltic pavement replacement shall conform to Section 4 (Asphalt Works) of these Specifications.

d. Method of Work – The individual pavement layers shall be cut back to produce steps a minimum of 600 mm wide between layers of the existing pavement.

   The faces of the layers shall be cut straight and vertical and shall be wire-broomed and painted with bituminous emulsion immediately prior to laying the replacement asphaltic courses.

   Asphaltic courses shall be laid in thickness and composition to match the existing pavement layers as far as is practical or as otherwise directed by the Engineer. Layers shall be laid and compacted in accordance with the requirements of Section 4 (Asphalt Works) of these Specifications with prime and tack coats as directed by the Engineer.

   The repair of all utility cuts shall be in full compliance with the requirements stipulated in Clause 407.03.4 of Section 4 (Asphalt Works) of these Specifications and the requirements for general pavement repair works of Clause 407 of Section 4 (Asphalt Works) of these Specifications.

   The top asphaltic layer shall be finished level and smooth with the existing pavement and under no circumstances shall the road be opened to traffic before all backfilling and replacement of asphaltic courses have been completed and approved in writing by the Engineer.

   Failure to obtain such approval prior to opening a highway to traffic shall be considered a serious breach of the Contract.

d. Removal and replacement of pavement courses are not allowed for utility crossings under motorways. In such cases, microtunneling shall be used in accordance with Section6, Clause 614 of these Specifications.

1701.02.2 Non-Asphaltic Pavement Courses

The removal of non-asphaltic pavement courses and the materials, equipment and method of work for the replacement of such courses shall be as shown on the Drawings, as specified in other of the Contract Documents and/or as directed by the Engineer.

Local excavations below subgrade level (if required) shall be filled to a level specified by the Engineer with subgrade material in layers not exceeding 150 mm and compacted using mechanical compactors to conform with the requirements of the relevant Specification.

Base course, if required, shall be placed in layers not exceeding 150 mm and compacted using mechanical compactors. Base course materials shall conform to the relevant requirements specified by the Engineer.

Prior to receiving bituminous materials the excavations shall be thoroughly cleaned. Subgrade, base course material shall be primed with a light coating of MC cutback bitumen and existing bituminous surfaces shall be lightly painted with tack coat in accordance with the requirements of Section 4 (Asphalt Works) of these Specifications

1701.02.3 Maintenance of Pavement Replacement

The completed replacement work shall be maintained by the Contractor for the period of the Contract. The Engineer shall instruct when repair work is required and, upon written instructions from the Engineer, the Contractor shall immediately carry out such repairs as are deemed necessary by the Engineer. All repair work shall be subject to written approval of the Engineer.

Repairs to the replaced pavement shall be carried out in accordance with the applicable Clauses of Section 4 (Asphalt Works) of these Specifications.

1701.02.4 Measurement and Payment

1701.02.4.1 Basis of Measurement and Payment

In locations where a pavement is to be re-opened to traffic (either temporarily or permanently) on completion of the construction work specified herein, all pavement repair works shall be measured as per the method of measurement described under Clause 407.04 of Section 4 (Asphalt Works) of these Specifications

Payment for the removal and replacement of pavement sections shall be made at the rates included in Section 4(Asphalt Works) of the Bills of Quantities and shall be deemed to include all materials, equipment, labour and other operations and obligations necessary to complete the work specified, and the subsequent maintenance thereof. Rates shall also include the cost of removal and reinstatement of kerbing associated with construction of the crossings.

In locations where a pavement is not to be so opened to traffic (and for permanent removal of temporarily reinstated works) measurement for removal of existing pavement courses shall be according to Clause 207.08 of Section 2 (Earthworks) of these Specifications, and payment shall be under Section 2 (Earthworks) of the Bills of Quantities.

1701.03 BREAKING OUT AND RESTORATION OF KERBING

1701.03.1 General

All materials and works shall be in accordance with Section 5 (Concrete Works) of these Specifications and as specified herein.

1701.03.2 Breaking Out of Kerbing

The following procedures shall be adopted for breaking out kerbing:

a. Remove pavement and tiles adjacent to the kerbing and break the mortar joint between the sound kerbstone and the kerbstones to be removed or reset.

b. Remove all broken and loose kerbstones, all foundations, haunches etc. and rubble and chisel off the mortar from the exposed edges of the sound kerbstones.

c. Cart all debris to approved dumping areas.

d. Set aside all acceptable kerstones for reuse. The Engineer shall be the sole judge of which, if any, kerbstones are acceptable for reuse.

e. The Contractor shall be responsible for ensuring that all reusable kerbs are kept protected until required for reuse. Any kerbs which at the time of reuse are, in the opinion of the Engineer, unsuitable, shall be removed from the Site to approved dumping areas and shall be replaced by the Contractor with new kerbs at the Contractor’s expense.

1701.03.3 Restoration of Kerbing

New kerbs shall be provided as necessary, in accordance with Section 5 (Concrete Works) of these Specifications, to match the existing kerbs. Where kerbs matching the existing are unavailable the Engineer shall direct the style of kerbing to be used.

After installation of the Utilities Structures and backfilling in accordance with these Specifications, the following procedures shall be adopted for restoring the kerbing:

a. Foundation – A plain concrete Class K180 foundation shall be laid to match the existing adjacent foundation except that the minimum width shall be 300 mm and the minimum depth 150 mm.

b. Where shown on the Drawings, the kerb foundations shall be cast on a layer of 1000 gauge polyethylene sheet and, where shown, shall incorporate vertical dowel bars in accordance with the details provided.

c. Kerbs – Either kerbs designated by the Engineer for re-use, or otherwise new kerbs, shall be set on a 20 mm thick sand cement (2:1) mortar bed and shall match the existing kerbing in line and level to the satisfaction of the Engineer.

d. Joints – All joints except expansion joints between kerbing shall be approximately 10 mm wide and shall be filled with a sand cement (2:1) mortar and cured using a liquid curing compound as directed by the Engineer.

e. Toe – A 100 mm x 150 mm Portland cement concrete toe shall be cast against the front of the kerstone using a Class K180 unreinforced concrete mix with a maximum aggregate size of 19 mm, and shall be cured with a liquid curing compound and as directed by the Engineer.

f. Haunch – A Class K180 plain concrete haunch shall be cast against the back of the kerb to the dimensions instructed by the Engineer with a minimum width of 120 mm and a depth to suit the kerb type and the adjacent sidewalk or median. The top surface of the haunch shall be finished level and the haunch shall be cured with a liquid curing compound as directed by the Engineer.

g. Where shown on the Drawings, the rear face of the kerb foundation and haunch and the front face of the kerb foundation or front casting shall be painted with two coats of an approved bituminous paint complying with the requirements of Clause 517 of Section 5 (Concrete Works) of these Specifications.

h. Expansion Joints – Expansion joints shall be constructed at intervals not exceeding 10 meters in the restored kerbing and in between the restored kerbstone and existing kerbstone. All expansion joints shall be formed with 10 mm thick filler board complying with ASTM D1751.

i. Tack Coat – The faces of the concrete and kerbstone which will be in contact with the asphalt concrete pavement shall be coated with bituminous emulsion.

1701.03.4 Maintenance

The Contractor shall promptly carry out all maintenance to the restored kerbing as directed by the Engineer in writing. All maintenance work shall be subject to the approval of the Engineer.

Repairs to installed kerbing shall be carried out in general accordance with this Clause 1701.03 and Section 4 (Asphalt Works) of these Specifications.

1701.03.5 Measurement and Payment

1701.03.5.1 Basis of Measurement and Payment

In locations where a pavement is to be re-opened to traffic (either temporarily or permanently) on completion of the construction work specified herein, measurement for the removal and reinstatement of existing kerbing shall be according to Clause 407.04 of Section 4 (Asphalt Works) of these Specifications.

In locations where a pavement is not to be so opened to traffic (and for permanent removal of temporarily reinstated works) measurement for removal of existing kerbing shall be according to Clause 207.08 of Section 2 (Earthworks) of these Specifications and payment shall be under Section 2 (Earthworks) of the Bills of Quantities.

1701.04 REMOVAL AND RESTORATION OF CONCRETE TILES AND BLOCKS

1701.04.1 General

All materials and work shall be in accordance with Section 5 (Concrete Works) of these Specifications and as specified herein.

1701.04.2 Breaking Out

The following procedures shall be adopted for removal of concrete tiles/blocks.

a. The concrete tiles/blocks shall be carefully removed and cleaned, with any mortar or other foreign matter being removed from the exposed faces.

b. All sound tiles/blocks designated by the Engineer for reuse shall be stored and protected until being incorporated in the Works. The Engineer shall be the sole judge of which, if any, of the tiles/blocks are acceptable for reuse.

c. All unusable tiles/blocks, broken pieces and other debris (mortar, concrete base, etc.) shall be removed and carted away to approved dumping areas.

d. The Contractor shall be responsible for ensuring that all reusable tiles/blocks are kept protected until required for reuse. Any tiles/blocks which in the opinion of the Engineer are unsuitable at the time of reuse shall be removed from the Site to approved dumping areas and shall be replaced by the Contractor with new tiles/blocks at the Contractor's expense.

1701.04.3 Restoration

New tiles/blocks shall be provided as necessary in accordance with Clauses 505 and 506 of Section 5 (Concrete Works) of these Specifications to match the size, thickness and style of the existing tiles/blocks as closely as possible. Where tiles/blocks matching the existing are unavailable the Engineer shall approve the style of tiling/block to be used.

After installation of the Utilities Structures and backfilling in accordance with these Specifications, the following procedures shall be adopted for restoring concrete tiles/blocks:

a. The foundation soil shall be excavated to a depth of 50 mm and carted away and disposed of at a location designated by the Engineer. The sub-grade shall be leveled and additional approved fill added as required to bring the level of the ground to between 100 mm and 150mm below the top level of the new tiles.

   If additional filling material is added, it shall be watered and mixed as necessary before compaction operations are carried out until a minimum of 95% of the maximum dry density is obtained when tested in accordance with AASHTO T.180., The leveling of the natural ground surface shall be done according to the proposed grades and slopes and any soil which is, in the opinion of the Engineer unsuitable, shall be removed from the Site.

b. A layer of clean sand, approximately 50 mm thick, shall be spread and compacted so that the required grades and levels are obtained before the concrete tiles/blocks are placed.

c. The new or reusable precast concrete tiles/blocks, shall then be placed directly on the sand layer without using any cement mortar.

d. In placing the concrete tiles/blocks, the Contractor shall ensure that the sides of tiles/blocks touch each other.

e. The tiles/blocks shall then be secured in place using light compactors while maintaining the proposed levels and grades.

f. Sand shall be used as filler between the tiles/blocks and vibrating plates shall be used to compact the sand into any gaps between the tiles/blocks.

g. Unless otherwise instructed by the Engineer, the placing of tiles shall be carried out in panels not exceeding 10 meter runs in any direction. These panels shall be separated by expansion joints formed of 10mm thick filler board conforming to ASTM D1751.

h. The concrete tiles/blocks shall be placed in a proper pattern to match the existing tiles/blocks unless otherwise directed or agreed by the Engineer. No tiles/blocks or any part thereof shall be cast in-situ, unless specifically approved by the Engineer.

1701.04.4 Maintenance

The Contractor shall promptly carry out all maintenance to the restored tiling/blocks as directed by the Engineer in writing. All maintenance work shall be subject to the approval of the Engineer.

Repairs to installed tiling/blocks shall be carried out in general accordance with this Clause 1701 and Section 4 (Asphalt Works) of these Specifications.

1701.04.5 Measurement and Payment

1701.04.5.1 Basis of Measurement and Payment

In locations where a concrete tile/block pavement is to be re-opened (either temporarily or permanently) on completion of the construction work specified herein, measurement for the removal and reinstatement of existing concrete tile/blocks pavements shall be according to Clause 407.04 of Section 4 (Asphalt Works) of these Specifications.

Payment shall be made at the rates included in Section 4 (Asphalt Works) of the Bills of Quantities and shall be deemed to include all materials, equipment, labour and other operations and obligations necessary to complete the work specified, and the subsequent maintenance thereof. Rates shall also include the cost of removal and reinstatement of kerbing associated with construction of the crossings.

In locations where a concrete tile/block pavement is not to be so re-opened (and for permanent removal of temporarily reinstated works) measurement for removal of existing concrete tile/block pavement courses shall be according to Clause 207.08 of Section 2 (Earthworks) of these Specifications, and payment shall be under Section 2 (Earthworks) of the Bills of Quantities.

The removal and re-erection of traffic signal installations shall be co-ordinated with the Ministry of Interior's Traffic Department, who shall direct and instruct the Contractor as to what measures are to be taken regarding the removal and re-erection of such items of street furniture.

1701.05 REMOVAL AND RESTORATION OF STREET FURNITURE

1701.05.1 General

Street furniture shall comprise road signs, bus stop signs, service or duct marker slabs and posts, street name signs, bus shelters, parking meters, street lighting columns, traffic signal installations and all other such items.

Where items of street furniture conflict with utility structures, they shall be carefully removed, cleaned, stored and re-erected on completion of the Utility Structure works either in their original position, or in an adjacent position, all as directed by the Engineer.

The removal and re-erection of all street lighting columns, or other street furniture having electrical connections, shall be co-ordinated with the Ministry of Electricity and Water, who shall direct and instruct the Contractor as to what measures are to be taken regarding the removal and re-erection of such items of street furniture.

1701.05.2 Removal of Street Furniture

All items of street furniture, unless designated by the Engineer as redundant, shall be carefully removed, cleaned of all foundation concrete and other debris and stored for reuse.

Any furniture which becomes damaged before re-erection shall be repaired by the Contractor to the satisfaction of the Engineer at the Contractor's expense.

All redundant furniture and debris shall be carted away to approved dumping areas.

1701.05.3 Re-erection of Street Furniture

Street furniture shall be re-erected in its original location or in an adjacent location as designated by the Engineer.

Suitable foundations shall be provided to match the original foundation or as directed by the Engineer.

Foundation concrete shall be Class K300 in accordance with Section 5 (Concrete Works) of these Specifications unless otherwise directed by the Engineer.

1701.05.4 Maintenance

The Contractor shall carry out all maintenance to the re-erected street furniture as directed by the Engineer in writing. All maintenance work shall be subject to the approval of the Engineer.

1701.05.5 Measurement and Payment

1701.05.5.1 Basis of Measurement and Payment

The method of measurement and payment for removal etc. of street furniture shall be as Clause 207.08 of Section 2 (Earthworks) of these Specifications and payment will be made under Section 2 (Earthworks) of the Bills of Quantities.

1702 - DUCT CROSSINGS

1702.01 GENERAL

uPVC pipes for electrical and telephone ducts shall meet the material requirements and Specifications of the Ministry of Electricity and Water and the Ministry of Communications as applicable or as directed by the Engineer. Concrete encasement of the ducts shall be in accordance with the Drawings and shall be in Class K180 concrete or as directed by the relevant Ministry. Split ducts shall be used on existing cables. Electrical and, where specified other, cable duct crossings without existing cables are to be provided with non-corrodable solid end plugs and the duct positions marked at both ends by service marker slabs, fence posts or indicator posts, all as shown on the Drawings or as directed by the Engineer. In addition, non-rotting draw cords are to be provided through the ducts during laying operations with one meter of cord coiled outside each end of the buried duct.

1702.02 EXCAVATION AND BACKFILLING

Excavation and backfilling for duct crossings shall be in accordance with Clause 605 of Section 6 (Stormwater Drainage) of these Specifications except as noted in Clause 1702.04 herein.

1702.03 CONCRETE WORKS

All concrete works, whether plain, reinforced, in situ or precast shall be carried out in accordance with Section 5 (Concrete Works) of these Specifications.

1702.04 METHOD OF CONSTRUCTION

The method of laying the ducts and backfilling shall be agreed with the Engineer prior to work starting on duct construction.

All ducts shall be constructed as shown on the Drawings with an approved method of maintaining the stipulated gaps between individual ducts. The Contractor shall obtain the Engineers' approval to the spacer style and material before commencing work.

Each duct shall be clean and no defective or broken ducts shall be used.

The ducts shall be laid straight in both the horizontal and vertical planes unless otherwise noted on the Drawings, and the ducts shall be approved by the Engineer before backfilling or concrete encasing commences.

The uPVC pipes shall be jointed with cement solvent as follows to result in water and gas-tight joints:

a. After cleaning the pipe ends from dirt, dust, grease, oil etc., for a minimum length of 100 mm, a thin coat of solvent cement shall be applied by brush on the inner side of the expanded end. The next pipe shall be then slid in and pushed until snugly fitted.

b. Joints shall not be disturbed for at least 30 minutes. At very low temperatures a longer time shall be allowed. In no circumstance shall dirt, grit or any foreign matter be allowed to enter the pipes.

For direct buried uPVC ducts the space between the ducts shall be carefully filled with sand free from large particles, stones and other objects liable to damage the pipes, and shall be hand rammed without the ducts being disturbed or damaged.

The completed duct shall be backfilled and hand rammed to a depth of at least 80 mm above the duct, thereafter backfilling shall continue in layers not exceeding 150 mm compacted thickness as specified in Clause 605.14 of Section 6 (Stormwater Drainage) of these Specifications.

1702.05 TESTING AFTER LAYING PIPES

After laying ducts and surrounding them in concrete, or backfilling the trench for direct buried ducts, a mandrel measuring 300 mm long and 10 mm less in diameter than the internal diameter of the ducts shall be pulled through each duct in both directions to ensure that there are no obstructions. Should any obstruction be met, the Contractor shall submit his proposals for removing the obstruction or for replacing the defective duct or ducts, at the Engineer's discretion, and at the Contractor's expense.

The proposals must be approved by the Engineer before any corrective measures are taken by the Contractor.

1702.06 SPLIT DUCTING EXISTING CABLES

Existing cables shall be protected by split ducting encased in concrete all as shown on the Drawings or as directed by the Engineer.

Existing cables shall be hand excavated and the use of power tools, pick axes or similar equipment shall not be permitted unless specifically authorised by the Engineer.

Split-ducting shall be of uPVC and the method of fixing the split ducts to ensure they are not disturbed during concreting shall be agreed with the Engineer prior to construction.

All relevant Clauses under 1702 herein shall apply to split ducting of existing cables.

1702.07 EXTENDING EXISTING DUCTS

Existing ducts shall be extended as shown on the Drawings and as directed by the Engineer. The Drawings are indicative only of the requirements and the method and style of extending the ducts shall be agreed with the Engineer when the existing ducts have been exposed and before construction of the extension commences.

The existing ducting to be extended shall be carefully exposed by hand excavation to avoid damage to the ducting and to establish whether there are any existing cables in the ducting.

The use of power tools, pick axes or similar equipment shall not be permitted unless specifically authorised by the Engineer.

Split-ducting shall be used to extend any ducts containing existing cables.

All relevant Clauses under 1702 herein shall apply to extending existing ducting except that the Engineer shall visually inspect the ducts on completion and shall approve or reject the ducting on the basis of this visual inspection.

The Engineer may also instruct that the mandrel test be performed but such test shall not govern the approval to the ducting.

1702.08 MEASUREMENT AND PAYMENT

1702.08.1 Method of Measurement and Basis of Payment

A. Trenches

Measurement of trench excavation for duct crossings shall be by the meter run for each duct configuration (excluding the length of manholes, handholes, etc.,) with separate pay items for each one meter depth stage.

Measurement for depth of trench shall be the average of the depth at each end, i.e. manhole to manhole, or end of duct to end of duct and shall be calculated from the existing ground level or from finished ground level, or from finished subgrade level, whichever is the lowest, to the trench invert level.

In the case where a duct or group of ducts is (I) partly in fill and partly in original ground or (II) totally above original ground level and is enclosed in fill, the measurement for depth shall be the lesser of dimensions (i) and (ii) as calculated below.

Dimension (i) - The depth between finished ground level or finished subgrade level, whichever is lower, and the trench invert level.

Dimension (ii) - The overall height of the duct configuration including any concrete surround plus 1000 mm.

Where trenches are to be excavated across existing roads or pavements which are to be re-opened to traffic on completion of the construction work specified herein, the depth of such trench excavation shall be calculated from the level of the top of the existing road or pavement to the trench invert level.

In locations where a pavement is to be re-opened to traffic (either temporarily or permanently) on completion of the construction work specified herein, removal and reinstatement of existing pavement courses, precast concrete tiles and street furniture, shall be executed in accordance with Clause 1701 of these Specifications.

Measurement and payment for such removal and reinstatement shall be in accordance with Clause 1701 of these Specifications and payment shall be made under the relevant Sections of the Bills of Quantities stated in Clause 1701 of these Specifications.

In locations where a pavement is not to be so re-opened to traffic (and for permanent removal of temporarily reinstated works); measurement for removal of existing pavement, precast concrete tiles/blocks and street furniture, shall be according to Clause 207.08 of Section 2 (Earthworks) of these Specifications, and payment shall be made under Section 2(Earthworks) of the Bills of Quantities.

Payment for trench excavation for each of the separate classifications shall be at the rate inserted in the Bills of Quantities, which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including excavation, where necessary hand excavation for extending existing ducting or protecting existing cables, backfilling, disposal of surplus excavated material, grading the trench bottom, upholding the sides of the excavation, de-watering and all other incidental work in connection with the construction.

B. Unsuitable Material Below Trench Bottom

Measurement for excavation of unsuitable material below the required trench bottom shall be by the cubic meter.

The trench width for measurement purposes shall be that show on the Drawings as the encasement width with no allowance being made for working space.

Payment shall be at the rate inserted in the Bills of Quantities and shall include the excavation and loading, carting away and dumping at approved dumping areas or deposition on Site all as directed or approved by the Engineer. The rate shall also include for backfilling with approved material as specified.

C. Rock Excavation

Unless described as included in the rates of excavation, measurement for rock excavation, as defined in Clause 203.05.4 of Section 2 (Earthworks) of these Specifications, shall be by the cubic meter irrespective of depth as

an extra over item to the main excavation measure. The volume shall be determined on the basis of encasement width shown on the Drawings for each duct configuration with no allowance for working space.

Payment shall be at the rate included in the Bills of Quantities, and shall include for the extra over cost of rock excavation, removal and hauling to approved dumping areas, or incorporation in the Works, as approved by the Engineer.

D. Direct Buried Ducts

Measurement of direct buried ducts shall be by the meter run of each duct configuration and type separately irrespective of the depth of laying.

Payment for direct buried ducts shall be at the rates inserted in the Bills of Quantities which rates shall include for all labour, plant and materials and everything necessary for the proper execution of the work including supplying and laying the ducts, all necessary jointing accessories, fittings, cutting of ducts, waste allowance, connections to existing fittings, testing and other work in connection with the construction, and including the provision and installation of draw wires, end plugs, marker slabs, fence posts and indicator posts where specified.

E. Concrete Encased Ducts

Measurement of concrete encased ducts shall be by the meter run for each duct configuration and type separately irrespective of the depth of laying.

Payment shall be at the rates inserted in the Bills of Quantities which rates shall include for all labour, plant, materials and everything necessary for the proper execution of the work including supplying and laying the ducts and split ducts, all necessary jointing accessories, fittings, cutting of ducts, waste allowance, connections to existing fittings, the supply and laying of concrete including laying the concrete bed under the pipes in a separate operation as necessary, all necessary formwork, testing and all other incidental work in connection with the construction, and including the provision and installation of draw wires, end plugs, marker slabs, fence posts and indicator posts where specified.

1702.08.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1702.1	Trench excavation for duct crossing (duct configuration, depth stages)	m
1702.2	Excavation of unsuitable material below trench bottom	cu.m
1702.3	Extra over for excavation in rock	cu.m
1702.4	Direct buried ducts (duct configuration, type)	m
1702.5	Concrete encased ducts (duct configuration, type)	m

1703 - MANHOLES AND CHAMBERS

1703.01 GENERAL

Manholes or chambers of the type and at the locations shown on the Drawings or as directed by the Engineer shall be provided. Concrete manholes and chambers shall comply with BS EN 1917 and BS 5911 Part 3. Thickness shall be as indicated on the Drawings.

1703.02 EXCAVATION AND BACKFILLING

Unless described otherwise, excavation and backfilling for manholes and chambers shall be in accordance with Clauses 208.01 to 208.07 of Section 2 (Earthworks) of these Specifications.

1703.03 CONCRETE WORK

All Concrete works, whether plain, reinforced, in situ or precast shall be carried out in accordance with Section 5 (Concrete Works) of these Specifications. Class of concrete shall be as specified except where otherwise shown on the Drawings.

1703.04 MANHOLE AND CHAMBER FURNITURE

The Contractor shall supply and install all necessary manhole furniture unless otherwise provided for in the Contract Documents. Manhole or chamber covers and frames shall be made of ductile iron and, unless otherwise shown in the Contract Documents, they shall be manufactured to BS EN124 Class D400 and be ventilated. They shall be of sound manufacture and free from projections and voids or other defects and coated to BS 3416. Minimum thickness 250 microns unless specified otherwise. Two sets of lifting keys shall be supplied with each removable cover. Covers shall bear the text insertion requested by the Employer.

Step irons shall be galvanized cast iron in conformity with the Drawings and with BS EN 13101 provided that the weight of the step iron is not less than 1.5 kg. Step irons shall be staggered at 300mm centres vertically and horizontally, and shall either be set in place or grouted in using epoxy grout.

Ladders shall be provided where the height from the benching to the cover is greater than 3metres as specified in Clause 604.06 of Section 6 (Stormwater Drainage) of these Specifications.

1703.05 PROTECTION OF MANHOLES AND CHAMBERS

Manholes and chambers situated wholly or partially below the ground water level shall be protected by membrane as specified in Clause 516 of Section 5 (Concrete Works) of these Specifications.

Unless described otherwise, manholes and chambers situated wholly above the ground water level shall be protected by painting as specified in Clause 517 of Section 5 (Concrete Works) of these Specifications.

1703.06 ADJUSTMENT OF MANHOLE OR CHAMBER LEVELS

1703.06.1 General

The work shall incorporate the raising or lowering of existing manhole or chamber covers to suit proposed ground or highway levels.

Where the change in level is minor, it will be possible to achieve the necessary modifications in the upper shaft of the manhole or chamber by removing or breaking out the upper shaft cover slab, reducing or increasing the height of the shaft walls, and replacing the shaft cover slab.

Where major level changes are required it will be necessary to remove or break out the upper shaft cover slab, demolish the upper shaft walls and the lower shaft cover slab, reduce or increase the height of the lower shaft walls, and reconstruct the lower shaft cover slab, upper shaft walls and upper shaft cover slab.

The Drawings indicate which manholes or chambers will be suitable for minor level changes and which will require major level changes. However, notwithstanding such information, the Contractor shall carry out a survey of the existing manholes or chambers, their cover levels and the height of the upper shafts, and establish for the Engineer's approval from consideration of proposed road or ground levels and from the details given on the Drawings, which manholes or chambers require minor level changes and which require major level changes.

The Contractor's attention is drawn to the fact that the Drawings and Specifications relate to typical situations and it is the Contractor's responsibility to carry out a full investigation and prepare all necessary details and working drawings for the Engineer's approval for the adjustment of the manhole or chamber levels to suit the proposed highway scheme.

No work shall commence on raising or lowering the manhole or chamber levels until approval to the Contractor's working drawings is given.

1703.06.2 Removal of Existing Upper and Lower Shaft Covers

The following procedures shall be adopted for the removal of existing shaft covers:

a. For precast upper shaft cover slabs, the cover slab shall be carefully removed and all loose or surplus mortar or other fixing agent chipped off. The Engineer shall determine whether the slab is suitable for reuse. If suitable it shall be set aside and protected until required. The Contractor shall take all responsibility of ensuring the slab remains undamaged until required for reuse. If at the time of reuse the slab is in an unacceptable condition in the opinion of the Engineer it shall be disposed of as outlined herein and be replaced by a new slab at the Contractor's expense.

b. For in-situ upper shaft cover slabs, the cover slab shall be broken out (without damage to the steel reinforcing in the shaft walls for manholes or chambers requiring minor level changes), and all debris carted away to an approved dumping area. Where shown on the Drawings or directed by the Engineer the manhole or chamber cover and frame shall be recovered.

c. For major level changes the upper shaft walls and lower shaft cover slab shall be broken out and all debris carted away to approved dumping areas.

   The upper or lower shaft walls shall be broken back to the extent required with care being taken to avoid damage to the reinforcement.

   The reinforcement shall be cut back to the required length for reconstruction purposes by means of cutting discs or cropping, flame cutting of the reinforcement will not be allowed. All surplus materials shall be discarded, reinforcement steel shall not be recovered or reused.

d. All manhole or chamber fittings, such as step irons, shall be carefully removed and stored for re-use or, if surplus to requirements, shall be cleaned and delivered to the MPW stores designated by the Engineer, or, if directed by the Engineer, shall be discarded.

e. For all demolition work, care shall be taken to avoid damage to the manhole or chamber and its fittings, and the method of demolition shall be subject to the Engineer's approval prior to commencing demolition work.

1703.06.3 Reconstruction

The manholes or chambers shall be rebuilt in accordance with the Drawings and these Specifications to suit the finished road or ground levels, all as directed by the Engineer.

All works shall be in accordance with the applicable clauses of Section 2 (Earthworks), Section 5 (Concrete Works), Section 6 (Stormwater Drainage), Section 12 (Metal Works) and Section 17 (Utilities Structures) of these Specifications.

1703.06.4 Manhole or Chamber Furniture

The covers shall be fixed on to the previously installed frames and bedded on a grease and sand mix.

Dimensions and types of covers and frames shall be as shown on the Drawings.

Each frame shall be fitted with a galvanised mild steel mud bucket to the dimensions and details shown on the Drawings.

Where recovered manhole or chamber covers and frames are not heavy-duty they shall be thoroughly cleaned and delivered to the relevant Service Authority stores as designated by the Engineer.

Where precast cover slabs are re-used the manhole or chamber cover shall be as specified above. Medium-duty covers shall be replaced by covers as specified above and the replaced cover shall be thoroughly cleaned and delivered to the relevant Service Authority stores as designated by the Engineer.

New manhole or chamber covers and frames, where required, shall be supplied by the Contractor.

Galvanised steel mud buckets shall be supplied by the Contractor for all reused cover slab manhole frames.

Details of the seating of manhole or chamber covers and frames on the upper shaft cover slabs under highways shall be as shown on the Drawings.

The provision of any step-irons, ladders, and any other manhole or chamber accessories and equipment etc. shall be as shown on the Drawings.

1703.06.5 Cleaning of Manholes and chambers

The insides of manholes or chambers shall be thoroughly cleaned of all debris and rubbish (whether resultant from the Contractor's work or not) which shall be carted to approved dumping areas.

1703.07 MEASUREMENT AND PAYMENT

1703.07.1 Method of Measurement and Basis of Payment

A. Manholes and Chambers

The approved work shall be measured by the number of each structure type and size constructed and installed including the supply and installation of frames, grates, covers, step irons, ladders and other furniture as applicable.

No separate measurement or payment shall be made for any concrete works, excavation, backfilling, shoring, sheeting, reinforcing steel, protective membrane, protective painting, rendering to sides or bottoms of structures, water stops, equipment, forms, tools, furnishing and placing materials, labor, or any other item necessary for the proper completion of the work or for breaking into existing pipes or culverts in order to install new manholes. All such additional items prescribed in this paragraph shall not be measured for direct payment, but shall be considered as subsidiary works, the costs of which shall be deemed to be included in the Contract prices for relevant structures.

Demolition of existing manholes or chambers shall be measured in accordance with Clause 207.08.1.H of Section 2 (Earthworks) of these Specifications.. Demolition of existing manholes in or around existing cables shall be measured separately, and rates shall include for all necessary work in connection with constructing the new manholes around the existing cables or pipes and for affording all protection to the existing cables or pipes.

Payment shall be at the rates in the Bills of Quantities which rates shall include for all labour, plant, excavation, installation, fitting, backfilling, forms, tools and materials and everything necessary for the proper execution of the work including all necessary temporary works, testing and other items and work in connection with the construction including connecting of existing pipes and ducts to the new construction.

B. Adjusting Manhole Levels

Measurement for raising existing manholes shall be enumerated for each type separately, stating the height raised in stages of 0.50 meters.

Measurement for lowering existing manholes shall be enumerated for each type separately, regardless of the depth lowered.

Concrete works, excavation, backfilling, shoring, sheeting, reinforcing steel, cover and frame, protective membrane, protective painting and re-arrangement of pipe entries and/or exits to manholes shall not be measured for direct payment, but shall be considered as subsidiary works, the costs of which shall be deemed to be included in the Contract prices for relevant Pay Items..

Unless described otherwise, raising inverts of existing manholes shall be enumerated, regardless of size, type or height raised.

Payment shall be under Section 17 of the Bills of Quantities and shall include for all labour, plant, excavation, installation, fitting, backfilling, forms, tools and materials and everything necessary for the proper execution of the work, including all necessary temporary works, testing and other items and work in connection with the construction, including connecting of existing pipes to the modified construction, and for affording all protection to the existing cables or pipes.

C. Rock Excavation

Rock shall be as defined in Clause 203.05.4 of Section 2 (Earthworks) of these Specifications with excavation carried out in accordance with Section 2 (Earthworks) of these Specifications. Unless described otherwise, payment shall be in accordance with Clause 205.01.4 of Section 2 (Earthworks) of these Specifications. Payment shall be made under Section 17 (Utilities Structures) of these Specifications.

1703.07.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1703.1	Manhole (type and size)	nr
1703.2	Chamber (type and size)	nr
1703.3	Demolition of existing manholes or chambers	nr
1703.4	Demolition of existing manholes in or around existing cables	nr
1703.5	Extra over for excavation in rock	cu.m
1703.6	Raising existing manhole level (type and height raised)	nr
1703.7	Lowering existing manhole level (type)	nr
1703.8	Raising inverts of existing manholes	nr

1704 - CULVERTS

1704.01 GENERAL

Reinforced concrete box culverts are to be constructed for relocated and future water, gas, oil and sewage pipelines, and/or around existing services all as shown on the Drawings.

All culverts are to be provided with access shafts with removable top slabs, with provisions for the construction of future pipe support plinths and with reinforced concrete block end walls all as shown on the Drawings or as directed by the Engineer.

For culverts built around existing pipes, the construction will include pipe support plinths and reinforced concrete block end walls with bitumen seals around the existing pipes unless otherwise shown on the Drawings or as directed by the Engineer.

All culverts are to be provided with ventilated manhole covers manufactured to BS EN124 Class D400 and galvanised mild steel mud buckets.

1704.02 EXCAVATION AND BACKFILLING

Excavation and backfilling for culverts shall be in accordance with Clause 208 of Section 2 (Earthworks) of these Specifications.

1704.03 CONCRETE WORKS

All concrete works for culverts whether plain, reinforced, in situ or precast shall be carried out in accordance with Section 5 (Concrete Works) of these Specifications.

1704.04 CONCRETE BLOCK WALLS

Construction requirements for concrete block walls shall be in accordance with the requirements for load bearing walls of Clause 505.04 of Section 5 (Concrete Works) of these Specifications.

1704.05 CLOSURE OF CULVERTS

Unless otherwise shown on the Drawings or directed by the Engineer the ends of culverts are to be sealed with double-skin reinforced concrete block walls tied with galvanised butterfly ties to the culvert walls and top and bottom slabs, with weep holes provided at the lower end of the culverts except where the culvert is below existing or expected ground water level. The details of end walls for culverts built around existing pipelines shall be as shown on the Drawings.

1704.06 CULVERT FURNITURE

1704.06.1 Access Shafts Covers and Frames

Access shaft covers and frames shall be made of ductile iron as noted in the Contract Documents and shall be manufactured to BS EN124 Class D400 and be ventilated as shown on the Drawings. They shall be of sound

manufacture and free from projections, voids or other defects and shall be coated to BS 3416. Minimum thickness 250 microns.. Two sets of lifting keys shall be supplied with each removable cover. Covers shall bear the text insertion requested by the Employer.

The cover shall be fixed on to the previously installed frames and bedded on a grease and sand mix.

Dimensions and types of covers and frames shall be as shown on the Drawings.

Each frame shall be fitted with a galvanised mild steel mud bucket to the dimensions and details shown on the Drawings.

The mud buckets shall be fabricated before galvanising and no modifications to the buckets shall be allowed after galvanising.

1704.06.2 Step Ladders

Step ladders shall be made of galvanised mild steel to BS 4211 and BS EN 14396. All components shall be hot dip galvanized to BS EN ISO 1461 with 610 grams of zinc per square meter. to the dimensions and configurations shown on the Drawings. All components shall be fabricated prior to galvanising and no modifications to the components shall be allowed after galvanising unless with the prior written approval of the Engineer.

All materials, welding, galvanising etc., shall be carried out in accordance with Section 12 (Metal Works) of these Specifications.

Support each ladder [at top and bottom and not more than 1500mm (60 inches) o.c.] with welded or bolted brackets, made from same metal as ladder.

1704.06.3 Samples

Prior to transporting any materials to the Site, the Contractor shall submit, for the approval of the Engineer, one sample of each type of cover and frame, one sample mud bucket and one sample of a section of a ladder to be used.

The sample length of ladder shall be a minimum of 2 meters long and shall be galvanised and shall show all major components including typical welds, holes (round and slotted), brackets, plates and fixing components.

All covers and frames, mud buckets, and ladders used shall conform to the approved samples. The approved samples shall be retained by the Engineer until the completion of the Project and shall then be returned to the Contractor who shall promptly remove them from the Site.

1704.06.4 Protection of Culverts

All culverts shall be protected as specified under Section 5 (Concrete Works) of these Specifications.

For culverts situated wholly or partly below the ground water level the culvert, including the end walls, shall be protected by membrane as specified in Clause 516 of Section 5 (Concrete Works) of these Specifications.

For culverts situated wholly above the ground water level the culvert, including the end walls, shall be protected by painting as specified in Clause 517 of Section 5 (Concrete Works) of these Specifications, unless described otherwise.

1704.07 MEASUREMENT AND PAYMENT

1704.07.1 Method of Measurement and Basis of Payment

A. <u>Earthworks</u>

The method of measurement and payment for earthworks shall be as specified in Clause 208.08 of Section 2 (Earthworks) of these Specifications. Payment will be made under Section 17 (Utilities Structures) of the Bills of Quantities.

B. Rock Excavation

Unless described as included in the rates of excavation, the method of measurement and payment for rock excavation shall be as specified in Clause 205.01.4 of Section 2 (Earthworks) of these Specifications. Payment will be made under Section 17 (Utilities Structures) of the Bills of Quantities.

C. Concrete Works

Measurement and payment of plain and reinforced concrete work shall be as specified in Clause 504.08 of Section 5 (Concrete Works) of these Specifications, and of surface finishes shall be as specified in Clause 504.05.3 of Section 5 (Concrete Works) of these Specifications. Payment will be made under Section 5 (Concrete Works) of the Bills of Quantities.

Measurement and payment of reinforcement shall be as specified in Clause 504.02.8 of Section 5 (Concrete Works) of these Specifications. Payment will be made under Section 5 (Concrete Works) of the Bills of Quantities.

D. Reinforced Blockwork End Walls

Measurement of reinforced concrete block end walls shall be by the square meter for the various thicknesses of blockwork shown on the Drawings.

Payment shall be at the rates inserted in the Bills of Quantities which rates shall include for all labour, plant and materials and everything necessary for the proper execution of the work including supplying and laying the blocks, reinforcement, all necessary jointing, all cutting of the blocks, providing and fixing all necessary wall ties, keeping cavities clear of mortar in the case of cavity walls, temporary works, testing and all other incidental work in connection with the construction.

E. Culvert Protection and Furniture

Items such as covers and frames, mud buckets, ladders, shall be measured by the number. Payment shall be at the rates included in the Bills of Quantities. The rates shall be deemed to cover the supply and installation of the above items including any specified protection treatment.

F. Protection of Culverts

Protective membrane, protective painting, and all other items necessary to construct the facility in accordance with the Drawings and Specifications shall not be measured for direct payment but shall be considered as subsidiary Works, the costs of which shall be deemed to be included in the Contract prices for relevant Pay Items.

1704.07.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1704.1	Structural Excavation	cu.m
1704.2	Extra over for excavation in rock	cu.m
1704.3	Reinforced concrete block end walls (thickness)	sq.m
1704.4	Covers and frames	nr
1704.5	Mud buckets	nr
1704.6	Ladders	nr

SECTION 18: MAINTENANCE AND PROTECTION OF TRAFFIC

1800 - GENERAL

1800.01 SCOPE

This work shall consist of maintenance and protection of traffic through or around areas of construction or maintenance. The work includes, but is not limited to, provision of detours and diversions, furnishing, erecting and maintaining temporary traffic control devices including barriers, barricades, cones, drums, warning signs and lights, road lighting, traffic signals and flagmen, all in conformance with these Specifications.

1800.02 RELEVANT AUTHORITIES

The Relevant Authorities referred to in the Documents with whom the Contractor will be required to discuss and coordinate the maintenance and protection of traffic proposals shall be as follows:

a. The Ministry of Public Works – Roads Administration Maintenance Department.
b. The Ministry of the Interior – General Traffic Department.
c. The Local Area Traffic Police for the area in which the maintenance and protection of traffic proposals are to be implemented.
d. The Kuwait Municipality – Safety Department.
e. The Kuwait Municipality – Fire Department.
f. The Kuwait Public Transport Company.
g. The various Service Ministries of Authorities whose plant and installations are affected by the proposals.

The Contractor will require the authorisation of the authorities listed as Items (a) to (d) above to obtain a permit to implement each stage or sub-stage of all road detours, diversions and maintenance and protection of traffic schemes.

1800.03 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

MUTCD	Manual of Uniform Traffic Control Devices for Streets and Highways, 2009.
AASHTO	A Policy of Geometric Design of Highways and Streets, 2004
KMTCD	Kuwait Manual on Traffic Control Devices
ANSI/ASEA	American National Standards Institution / International Safety Equipment Association
ANSI 107-2004	High Visibility Garment Standard
ITE	Institute of transportation Engineers
EN 471	High Visibility Warning Clothing

1801 - TRAFFIC CONTROL DEVICES

1801.01 GENERAL

Traffic control devices shall conform to the requirements of these Specifications and to the “Kuwait Manual on Traffic Control Devices”. All traffic control devices shall be approved by the Engineer before installation on the site. After initial use is complete the Contractor may reuse any approved item as the need arises. Unless otherwise shown on the Drawings, the installation, layout, and removal of traffic control devices shall comply with the ‘Traffic control for road works’ manual.

1801.02 MATERIALS REQUIREMENT

Traffic control devices shall meet the following materials requirements.

1801.02.1 Reflectorisation

All sign panels, barricades, drums, vertical panels and flagmen's paddles shall be reflectorised by use of reflectorised sheeting meeting the minimum requirements of Type I, enclosed lens as Specified in Section 7 (Traffic Markings and Signs) of these Specifications. Painting shall not constitute an approved substitute for achieving reflectorisation.

1801.02.2 Construction Signs

a. Sign panels shall conform to Section 7 (Traffic Markings and Signs) of these Specifications and to the "Kuwait Manual on Traffic Control Devices" and shall be as shown on the Drawings.

b. Unless otherwise approved by the Engineer, sign posts shall be of 100 x 100 mm nominal sound seasoned soft wood free of excessive knots, acceptable to the Engineer and conforming to Section 19 (Timber Structures) of these Specifications. The sign posts shall be drilled with breakway holes as shown on the Drawings or as directed by the Engineer.

1801.02.3 Barricades

Barricades shall be made of metal or plastic and shall collapse when tipped over, Barricades made of wood will not be permitted.

1801.02.4 Cones

Cones shall be manufactured of a material capable of withstanding impact without damage to the cones or vehicles. All cones shall be red coloured with a white reflectorised band as indicated on the Drawings. The band shall have a reflective intensity complying with the minimum requirements of Type 1, enclosed lens sheeting as specified in Section 7 (Traffic Markings and Signs) of these Specifications. Cones shall be capable of remaining upright during normal traffic flow and wind conditions in the area where they are used. Cones shall be a minimum of 750mm and a maximum of 1000mm in height. All the cones used on any one section of the Works shall be of the same height.

1801.02.5 Vertical Panels

Vertical panels shall be constructed of metal or plastic and those made of wood will not be permitted.

1801.02.6 Drums

Drums shall be plastic or other synthetic material approved by the Engineer of approximately 200 litre (55 gallon US) capacity, and shall be purpose-made for traffic control. Drums made of metal will not be permitted.

Drums shall be of a shape that will resist rolling if knocked over and they shall be reflectorised and coloured red with a white band at mid-height in accordance with the "Kuwait Manual on Traffic Control Devices". Where considered necessary by the Engineer, the drums shall be weighted with sand or water..

1801.02.7 Temporary Metal Beam Guard Rail

Temporary guardrail shall conform to the applicable Clauses of Section 12 (Metal Works) of these Specifications. Used guardrail material will be permitted providing it is neat in appearance, straight, and is approved by the Engineer.

1801.02.8 Temporary Concrete Barriers

Temporary concrete barriers shall conform to the requirements of Section 5 (Concrete Works) of these Specifications and shall be as shown on the Drawings. Unless otherwise directed by the Engineer, temporary concrete barriers shall have Type C warning lights fixed to the top of the barriers at 6 m centres.

The Ministry of Public Works may furnish some or all of the temporary concrete barriers. It shall be the Contractor's responsibility to collect the barriers from the designated Ministry of Public Works store, load and transport to the site of the Works, unload and position.

Should the Ministry of Public Works be unable to furnish sufficient or any temporary concrete barriers, the Engineer will instruct the Contractor to provide such as are required.

On completion of the Contract all barriers, whether provided by the Ministry of Public Works or by the Contractor, shall become the property of the Employer and shall be delivered to a Ministry of Public Works' storage area as directed by the Engineer.

1801.02.9 Warning Lights

Warning lights shall be Type A (low intensity flashing), Type B (high intensity flashing), or Type C (steady burn), and shall meet the minimum requirements of the Institute of Transportation Engineers "Standard for Flashing and Steady-Burn Barricade Warning Lights", insofar as the I.T.E standard does not conflict with the "Kuwait Manual on Traffic Control Devices".

Arrangements, responsibilities and charges for power supply shall be as described for temporary lighting in Clause 1801.02.13 of these Specifications. No power supply shall be taken from any Ministry of Electricity and Water source, including permanent or temporary street lighting circuits, without the prior written approval of Ministry of Electricity and Water.

1801.02.10 Flashing Arrow Boards

Flashing arrow boards shall be a minimum of 1200 mm high and 2400 mm wide, and shall be finished with flat black enamel. A minimum of fifteen, 150mm diameter, amber lamps shall be installed in the panel. The lamp configuration shall be provided with a visor, and the lamps, when illuminated, shall be visible on a clear, cloudless day, for a minimum distance of 1500 m. Flashing arrow boards having only pointing arrow heads (chevrons) shall not be used.

Four selectable modes of operation shall be provided as follows:

a. Pass Left Mode – Lighted arrow flashing left.
b. Pass Right Mode – Lighted arrow flashing right.
c. Pass Right and Left Modes – Lighted arrow flashing right and left simultaneously.
d. Caution Travel Mode – The outside top and bottom lamps on the panel flashing on and off simultaneously (in a pattern which will not indicate a direction).

The electronic circuitry shall provide between 35 and 50 complete, and equally spaced, operating cycles of the sign per minute in each of the modes specified above. The power source and the controls used for the lights shall be reliably governed and voltage stabilized so as to provide the required equally spaced operating cycles. The Engineer will reject the use of any power source which does not provide this.

A switch controlled variable dimming device shall be provided on the control panel which will reduce the voltage on the lamps (dimming) to a minimum of 50% for night time use. Arrow boards shall be mounted to provide a minimum of 2100 mm between the bottom of the board and roadway.

Where the arrow board is mounted on a towable trailer, the trailer shall be fitted with a parking brake or other device, which shall be approved by the Engineer, and which will prevent the trailer moving under the effect of wind or air turbulence from passing traffic.

Any generator used for powering the flashing arrow board shall not leak oil or fuel onto the road or ground, and care shall be taken to avoid spillage during refuelling. Any asphalt road surface which, in the opinion of the Engineer, has become contaminated by oil or fuel shall be cut out and reinstated to the Engineer's satisfaction at the Contractor's expense.

Arrangements, responsibilities and charges for power supply shall be as described for temporary lighting in Clause 1801.02.13 of these Specifications. No power supply shall be taken from any Ministry of Electricity and Water source, including permanent or temporary street lighting circuits, without the prior written approval of Ministry of Electricity and Water.

1801.02.11 Temporary Traffic Markings

a. **Temporary Painted Markings** - Temporary painted traffic markings shall conform to the requirements of Section 7 (Traffic Markings and Signs) of these Specifications.

b. **Temporary Tape Markings** – Temporary traffic tape markings shall consist of glass spheres, complying with the requirements of Section 7 (Traffic Marking and Signs) of these Specifications, embedded into a binder on a suitable backing that is pre-coated with a pressure sensitive adhesive. The spheres shall be of uniform gradation and distributed evenly over the surface of the tape. The colour of the tape shall conform to colour tolerance for traffic marking paint, as required in Section 7 (Traffic Markings and Signs) of these Specifications, and be readily visible when viewed under vehicle headlights at night. The pavement marking tape, when applied in accordance with manufacturer's recommended procedures, shall be weather resistant and shall show no appreciable movement, fading, lifting, or shrinkage during the useful life of the marking. The tape, as supplied, shall be of good appearance, free of cracks, and edges shall be true, straight, and unbroken. Only tape specifically designed for this use will be permitted. Use of foil-backed tape will not be permitted.

1801.02.12 Raised Pavement Markers

Raised pavement markers shall conform to Section 7 (Traffic Marking and Signs) of these Specifications. Non-reflective markers (Type n) shall be white or silver as directed by the Engineer.

1801.02.13 Temporary Lighting

The Ministry of Electricity and Water may furnish used single or twin-arm light standards 9 m to 16 m (nominal) high with ballast and luminaries but without lamps and cut-outs. The Contractor shall be responsible for collecting light standards from the Ministry of Electricity and Water.

Should the Ministry of Electricity and Water be unable to furnish used light standards and fittings, the Engineer will instruct the Contractor to provide single or twin-arm 12 m standards with one lantern and 400 Watt mercury vapour lamp per arm complete with ballasts.

The Contractor shall furnish and install all cables, foundations, control cabinets, photo cells, lamps, cut-outs and everything else necessary to provide a complete lighting installation, all as specified in Section 14 (Lighting and Electrical Works) of these Specifications.

During the construction of the Works, temporary light standards may be required to be removed and reinstalled in other locations as directed or approved by the Engineer to suit the phasing of the Works.

The Contractor shall be responsible for making the necessary arrangements with the Electrical Distribution Network Section of the Ministry of Electricity and Water for the connection of the control cabinets of the lighting systems to the power supply network. A formal application for connection must also be made to Ministry of Electricity and Water through the Engineer. Adequate notice shall be given to the Engineer to permit the processing of this application. Connection to the network will be carried out by Ministry of Electricity and Water. Any connection charges shall be the responsibility of the Contractor. The cost of electricity used for temporary lighting systems will not be charged to the Contractor.

All regulations of the Ministry of Electricity and Water shall be strictly observed in the distribution and use of the supply. Under no circumstances shall any installation be connected to the mains supply until authorised by the Engineer.

The nominal voltage of the mains power to be supplied by the Ministry of Electricity and Water is 240 volts, single phase at a nominal frequency of 50 Hz.

1801.02.14 Temporary Traffic Signals

Temporary traffic signals are to be provided by the Contractor and shall be approved by the Engineer. The signals used shall be multi-pole units complete with a controller covered by a sunshade, as shown on the Drawings. The poles shall be fitted with either one or two sets of three standard lanterns.

All temporary traffic signal installations shall be to the approval of the Engineer and the Traffic Department of the Ministry of the Interior, and shall be in general conformance with Section 16 (Traffic Control System) of these Specifications.

Pre-timer control or alternative methods of vehicle detection may be proposed by the Contractor where signals are proposed for short-term operation. These proposals shall be approved by the Engineer and the Traffic Department of the Ministry of the Interior before being implemented.

Arrangements, responsibilities and charges for power supplies shall be as described for temporary lighting in Clause 1801.02.13 of these Specifications. No power supply shall be taken from any Ministry of Electricity and Water source, including permanent or temporary street lighting circuits, without the prior written approval of Ministry of Electricity and Water.

1801.03 FLAGMEN

Persons acting as Flagmen shall be physically and mentally qualified, trained in their duties and courteous. For daytime and nighttime activity, flaggers shall wear high-visibility safety apparel that meets the Performance Class 2 and 3 requirements, respectively, of the American National Standards Institution / International Safely Equipment Association 107-2004 publication entitled “American National Standard for High-Visibility Apparel and Headwear”, or equivalent versions, and labeled as meeting the ANSI 107-2004 standard performance for Class 2 and 3 risk exposure, respectively. The apparel background (outer) material color shall be either fluorescent orange-red or fluorescent yellow-green.. High visibility clothing shall be kept clean and that which, in the opinion of the Engineer, has become so dirtied that it is no longer effective shall be cleaned or replaced.

The retroreflective material shall be orange, yellow, white, silver, yellow-green, or a fluorescent version of these colors, and shall be visible at a minimum distance of 300 m.

1802 - APPLICATION OF TRAFFIC CONTROL DEVICES

1802.01 GENERAL

Traffic control devices shall be provided and maintained both inside and outside the Contract Limits as needed to facilitate traffic guidance and to ensure that all traffic, whether vehicular or pedestrian, will be accommodated safely.

Prior to start of construction operations, the Contractor shall erect such signs, cones, drums, barricades, and other traffic control devices as may be required in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer. During non-working hours and following completion of a particular construction operation, all warning signs, except those necessary for the safety of the public, shall be removed or entirely covered with metal, plywood, or other sheet approved by the Engineer, so that the entire sign panel will be invisible to traffic.

Traffic control devices shall be in place and operated only as long as they are needed. Only those devices that apply to conditions actually in existence shall be in place. If not needed, the traffic control devices shall be transported to a storage area for further reuse on the project.

1802.02 REFLECTIVE MATERIALS

Reflective materials on signs, drums, barricades, and other devices shall be kept clean, free from dirt, dust, mud and road grime. Scratches, rips, and tears in the sheeting shall be promptly repaired by the Contractor to the Engineer's satisfaction. Reflective sheeting materials shall maintain a reflectivity of not less than 50% of the minimum intensity values specified in Clause 1801.02.1 of these Specifications.

1802.03 SIGN PANELS, BARRICADES, CONES, VERTICAL PANELS AND DRUMS

Sign panels, barricades, cones, vertical panels and drums shall be installed as shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

These devices shall be supplied and maintained by the Contractor and they shall be relocated, realigned or replaced as necessary. Any traffic control devices provided under this Clause which are damaged, lost, stolen, destroyed or deemed unacceptable while their use is required on the Contract shall be promptly replaced by the Contractor without additional payment or compensation.

All traffic control devices referred to in this Clause shall remain the property of the Contractor. The Contractor shall not remove any item from the Contract without the Engineer's written agreement.

1802.04 TEMPORARY METAL BEAM GUARDRAILS

Temporary metal beam guardrails shall be installed where shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer. The Contractor shall maintain the guardrails and shall promptly replace all damaged sections.

During construction of the Works, the temporary metal beam guardrails may be required to be removed and reinstalled in other locations as directed or approved by the Engineer.

1802.05 TEMPORARY CONCRETE BARRIERS

Temporary concrete barriers shall be installed where shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer. The Contractor shall maintain the barriers and shall promptly replace, repair or realign, as directed by the Engineer, all damaged or displaced sections.

During the construction of the Works, the temporary concrete barriers may be required to be removed and reinstalled in other locations as directed or approved by the Engineer.

1802.06 WARNING LIGHTS

Type A warning lights shall be securely fixed to barricades or drums used singly or installed as shown in the Contract Documents, or on proposals, submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

Type B warning lights shall be securely fixed to warning signs, barricades, and independent supports shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

Unless otherwise specified, Type C warning lights shall be securely fixed to barricades, temporary concrete barriers or drums as shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

1802.07 FLASHING ARROW BOARDS

Flashing arrow boards shall be installed or positioned as shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

1802.08 TEMPORARY TRAFFIC MARKINGS

1802.08.1 General

Thinly applied Hot-Sprayed Thermoplastic layer, Reflectorised Traffic Paint or Temporary Traffic Tape may be used for temporary pavement markings. In determining the type of marking to be used the Engineer shall consider the duration the detour will be in use and the requirement to maintain a high standard of marking at all times.

Before applying any temporary pavement marking, the Contractor shall demonstrate to the Engineer's satisfaction that the markings can be removed as specified herein.

Temporary traffic markings shall be installed as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer and shall be in conformance with the following requirements:

a. The style of traffic markings shall be established in accordance with these Specifications and the Kuwait Manual on Traffic Control Devices and shall be neat in appearance.
b. Broken striping shall be as Section 7 (Traffic Markings and Signs) of the Specifications excepting that the width shall be 150 mm.
c. Solid striping shall be 150 mm wide.
d. Gaps between adjacent striping shall be 175 mm wide.

1802.08.2 Removal of Painted Pavement Markings

All conflicting construction striping and other pavement markings shall be removed to the fullest extent possible by sand-blasting or by some other approved method that does not materially damage the surface or texture of the pavement. Painting-out of conflicting markings shall not be permitted. The removal pattern shall be of a shape that does not perpetuate the outline of the removed marking. Any damage to the pavement surface shall be repaired by the Contractor at his own expense by methods acceptable to the Engineer. Accumulations of sand or other material which might constitute a traffic hazard shall be removed. Sand-blasted areas shall be lightly coated with an asphaltic emulsion or approved equal after inspection and approval by the Engineer. All the foregoing operations shall be complete to the satisfaction of the Engineer prior to opening to traffic.

1802.08.3 Opening of Roads and Detours

No road or detour shall be opened to traffic before all applicable traffic markings have been installed and all conflicting markings removed to the satisfaction of the Engineer except for the markings at junctions of Detours and existing roads which markings shall be installed and/or removed immediately after the road or detour is opened or closed.

1802.09 TEMPORARY RAISED PAVEMENT MARKERS

Temporary Raised pavement markers shall be installed where shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer. Installation of temporary markers shall be in accordance with manufacturer`s instructions and shall be cemented to the surface with the adhesive recommended by the manufacturer, and the procedures set out in Section 7 (Traffic Markings and Signs) of these Specifications unless approval is given in writing by the Engineer to other methods of fixing.

Where such markers are to be removed but the road surface is to remain in use, the markers shall be carefully removed with the minimum of damage to the road surface. Any damage to the surface shall be made good at the Contractor's expense with materials and in a manner approved by the Engineer.

1802.10 TEMPORARY LIGHTING

Temporary lighting shall be installed where shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer. The location and spacing of light standards shall be approved by the Engineer unless the required spacing is indicated on the Contract Drawings.

The Contractor shall maintain the temporary lighting installations and shall carry out routine inspections to ensure all installations are functioning satisfactorily.

The Contractor shall promptly replace or repair any faulty or malfunctioning lamps or installations. The Engineer shall be informed promptly of any traffic damaged installation and such installation shall be replaced or repaired as directed by the Engineer.

During the construction of the Works, temporary lighting may be required to be removed and re-installed in other locations as directed or approved by the Engineer.

1802.11 TEMPORARY TRAFFIC SIGNALS

Where the maintenance of traffic scheme requires the installation of traffic signals at a junction where there are no existing signals the Contractor shall supply and install all temporary signal control equipment.

At existing signal – controlled junctions the Contractor shall utilise the existing equipment and shall supply and install such additional equipment required for any modified road layout or traffic management system at the junction.

The Contractor shall modify the temporary signal installation to suit the various detour and traffic management stages and shall supply and install all additional equipment required to maintain continuous operations of the traffic signals while transferring from one detour or traffic management stage to another.

The Contractor shall maintain the temporary traffic signal installation and shall replace promptly any broken lamps and shall replace and repair any damaged or malfunctioning equipment.

Unless otherwise agreed with the Engineer the new permanent traffic signal equipment shall not be installed at a junction until the permanent carriageway works are complete at the particular junction.

1802.12 DUST CONTROL

The Contractor shall, to the maximum extent possible, prevent nuisance due to dust raised as a result of delivery of materials, excavation, backfilling, stockpiling, loading or unloading, hauling, the construction and maintenance of Detours or any other of his operations. Dust control shall be by watering by tanker trucks with spray attachments or by other approved methods.

1802.13 FLAGMEN

Flagmen shall be used only where approved by the Engineer and the Relevant Authorities. They shall not be used for night-time operations unless approved by the Engineer.

1802.14 FAILURE OF THE CONTRACTOR TO COMPLY

Should the Contractor fail to provide satisfactory maintenance and protection of traffic through areas of construction, or should he fail to adequately maintain access to properties and facilities affected by the Works, or should he fail to furnish, maintain, repair or replace any traffic control devices within 24 hours of being given written notice by the Engineer, the Employer shall apply a penalty in accordance with Clause 102.15 (Failure of the Contractor to Comply) of Section 1 (General) of these Specifications.

1802.15 RECOVERY OF MATERIALS

On completion of the Works or when no longer required, the Contractor shall remove, transport and place in a Ministry of Electricity and Water storage yard designated by the Engineer, all light standards and lighting appurtenances whether initially provided by Ministry of Electricity and Water or by the Contractor. All materials for Ministry of Electricity and Water storage shall be cleaned of dirt, concrete and deleterious coatings to the approval of the Engineer.

On completion of the Works or when no longer required, the Contractor shall remove, transport and place in a MPW storage yard designated by the Engineer, all temporary concrete barriers whether initially provided by MPW or by the Contractor. All materials for MPW storage shall be cleaned of dirt and deleterious coatings to the approval of the Engineer.

Asphaltic Pavement materials shall be recovered and stockpiled in locations designated by the Engineer in accordance with Sections 2 (Earthworks) and 4 (Asphalt Works) of these Specifications.

All other traffic control devices shall become the property of the Contractor and when no longer required shall be removed from the Works.

1803 - TRAFFIC SAFETY SUPERVISOR

1803.01 GENERAL

The Contractor shall provide a competent Traffic Safety Supervisor who shall be approved by the Engineer and who shall be responsible for the Contractor's maintenance and protection of traffic operations. This Supervisor shall be contactable and available at all times during the Contract period and shall have received traffic safety training or shall have had previous experience in supervising maintenance and protection of traffic through highway construction work areas including Expressways and other high-speed / high traffic volume roads.

1803.02 DUTIES

The Contractor's Traffic Safety Supervisor's duties shall include, but not be limited to, the following:

a. Understanding the requirements of these Specifications and the Contract Documents.
b. Assuring compliance of the Contractor's maintenance and protection of traffic activities as required by the Contract Documents.
c. Taking responsibility for coordination with, and gaining approvals from, all relevant Authorities for the maintenance and protection of traffic operations as required by the Contract Documents.
d. Routinely inspecting the condition and position of traffic control devices in use on the Works and ensuring that they are in proper working order, clean, visible and conforming to the Drawings, the approved detailed detour Construction drawings and these Specifications.
e. Reviewing and anticipating appropriate traffic control device needs, advising the Engineer thereof, and ensuring that such devices as are determined to be necessary for safe and efficient traffic movement are obtained and placed at the required time.
f. Coordinating maintenance and protection of traffic operations with the Engineer.
g. Reviewing the Contractor's equipment operations and storage, and his materials handling and storage with respect to traffic safety and operation as required by the Contract provisions.
h. Holding an initial traffic safety meeting with the Main Contractor's and Subcontractor's Superintendents and Foremen prior to beginning construction and periodic meetings (at least monthly) thereafter as deemed necessary or as directed by the Engineer. The Engineer shall be provided with the opportunity to attend these meetings and shall be issued with concise notes or minutes of these meetings whether attended by him or not.

1804 - LIMITATION OF OPERATIONS

1804.01 GENERAL

The Contractor's operations shall be limited as follows:

a. All persons employed on installation, maintenance and removal of traffic devices and on the Works shall wear an orange high visibility and reflective jacket conforming to EN 471, Class 3, or similar approved by the Engineer and orange or light-coloured safety helmets. High visibility clothing shall be kept clean and that which, in the opinion of the Engineer, has become so dirtied that it is no longer effective shall be cleaned or replaced.

b. Vehicles employed on installation, maintenance and removal of traffic devices or on the Works shall be equipped with conspicuity devices approved by the Engineer. As a minimum, each vehicle shall be equipped with two flashing amber beacons which shall be clearly visible all around the vehicle.

c. Vehicles shall only enter and leave a works area which is under Maintenance and Protection of Traffic by means of designated and properly signed entrance and exit points approved by the Engineer.

d. No work shall be performed during the hours of darkness unless authorized in writing by the Engineer.

e. Night-time construction operations, where authorised by the Engineer, shall be illuminated by a lighting system approved by the Engineer. The lighting system shall be positioned and operated to preclude glare to approaching vehicles.

f. The Contractor's equipment shall be operated in the direction of traffic wherever practical.

g. Insofar as is practicable, the construction of adjacent traffic lanes shall be completed to the same elevation within the same or subsequent workday. Where not practicable, suitable arrangements shall be made to protect traffic to the approval of the Engineer.

h. The Contractor will coordinate with the Engineer on locations for staging areas. Selection of all staging areas is subject to the approval of the Engineer. The boundary of all staging areas shall be located at least 10 m from the edge of pavement. Access and egress from the staging area shall only be from designated locations which shall have adequate sight distances, shall be properly signed, and shall be subject to the approval of the Engineer.

i. During non-work hours, pavers and rollers shall be parked in the staging areas, or 10 m from the edge of the pavement. When it is impractical to meet these restrictions, due to land features or restrictions, pavers and rollers may be parked as far from the pavement edge as possible with a minimum distance of 2 m, as approved by the Engineer. An adequate number of barricades, with Type A warning lights, shall be placed on the pavement side of the parked pavers and rollers and the cost will be borne by the Contractor. All other equipment shall be stored at approved staging areas.

j. Private vehicles, belonging to the Contractor's employees, shall be parked in areas approved by the Engineer and at no time shall private vehicles belonging to the Contractor's employees be parked within 10 m of traffic lanes.

k. Contractor's material shall be stored at the approved Contractor's staging areas or at other locations approved by the Engineer. If suitable areas within the project limits are not found to be adequate for the Contractor's storage plant or office requirements, the Contractor shall be responsible to find other areas outside the project limits. All costs associated with the additional areas obtained shall be borne by the Contractor.

l. The Contractor shall provide equipment for communications between the Works, flagmen where used, and the mixing or batching plant, and shall make such equipment available to the Engineer for the proper coordination of the Work, and for maintenance and protection of traffic.

m. The Contractor shall schedule operations to minimise potential traffic backups.

n. The Contractor shall not switch traffic routes for the closure or opening of lanes, diversions or detours without first having:

i The approval of the Engineer and all Relevant Authorities.
ii Adequate equipment and personnel on Site to remove and set up all traffic control devices as approved by the Engineer.
iii Adequate equipment and personnel on Site to install any necessary road markings in conjunction with the switching of traffic routes.
iv Adequate communications to control traffic safety.
v. All equipment and materials removed from the travelled way.

o. With the prior approval of the Engineer and other Relevant Authorities, certain minor roads may be operated, on a temporary basis, on a one-way-reversible-flow system. A minimum lane width of 3.5 m shall be maintained and traffic shall be regulated by temporary traffic signals. STOP/GO signs operated by flagmen may only be used in lieu of traffic signals with the approval of the Engineer and the Relevant Authorities.

p. The Engineer may suspend the performance of the Works, either in whole or in part, should, in the Engineer's opinion, unsafe traffic management related work methods take place or excessive traffic delays occur during a construction operation. In either case, work will not be permitted to recommence until the reasons for the suspension are corrected to the Engineer's satisfaction.

1805 - MAINTENANCE OF ACCESSES

1805.01 GENERAL

The Contractor shall ensure that adequate access is maintained at all times to properties and facilities affected by the Works.

Such properties and facilities shall include, but not be limited to, all public and private buildings, houses, garages, parking areas, gardens, services (sub-stations, pump stations, manholes, pipelines, valve chambers etc.), shops or any other facility designated by the Engineer.

As a minimum, accesses shall be replaced with the same width, standard and surface type as the existing access facilities, but in all cases a construction of all accesses shall be agreed with the Engineer prior to construction.

The locations of accesses to be maintained are not shown on the Drawings, and the Contractor shall understand that any existing access whether public or private, paved or unpaved shall be maintained at all times during the Contract period unless specifically authorised otherwise by the Engineer in writing.

1806 - TEMPORARY, TOTAL OR PARTIAL CLOSURE OF ROADS

1806.01 SCOPE

With the approval of the Engineer and all Relevant Authorities, the Contractor may temporarily, totally or partially close existing roads to traffic. Approval shall not normally be given to total closure or partial closure of lengths in excess of 500 m.

Unless agreed otherwise in writing by the Engineer, accesses shall be maintained at all times in accordance with Clause 1805 of these Specifications.

1806.02 DEFINITIONS

a. A temporary total closure of a road shall comprise the closure of a road to all through vehicular and, if approved by the Engineer, all pedestrian traffic movements.

b. A temporary partial closure of a road shall include, but not be limited to, the following:

i. Closure of a lane or lanes of one or both carriageways of a dual carriageway.
ii. Reduction in width of lanes of dual carriageways.
iii. Closure of lanes of two-way roads.
iv. Reduction in width of two-way roads.

1806.03 GENERAL REQUIREMENTS

In presenting his proposals for a temporary, total or partial closure of a road, the Contractor shall show the alternative roads which may be used by traffic, together with all necessary signage and traffic control device layouts to ensure the free flow of traffic and the safety of traffic, pedestrians and properties. The Contractor shall also indicate how vehicular and pedestrian access will be maintained to affected properties and facilities, and the timetable for the road closure indicating whether it will be permanent for the stated duration or only operative at certain times of the day/night.

The Contractor shall include in his proposals any temporary minor construction works (road widening, amending corner radii, temporary ramps etc.) which may be necessary to ensure satisfactory maintenance and protection of traffic and to gain the approval of the Engineer and of the Relevant Authorities to his proposals.

If required by the Engineer, the Contractor shall promptly make any amendments to his proposals, including the provisions of additional or alternative traffic control devices.

The Contractor shall provide the alternative roads, or parts thereof, with additional signs, traffic markings, temporary lighting, traffic signals and other traffic control devices as determined necessary by the Engineer or any Relevant Authority.

Should the Engineer or any of the Relevant Authorities refuse the Contractor permission to institute a temporary, total or partial closure of a road, not forming part of the Detour concepts shown in the Contract Documents, the Contractor shall not be entitled to any time extension or financial compensation.

On completion of the total or partial closure of a road, the Contractor shall remove all temporary construction, and traffic control devices and shall restore the site to its original condition or such other condition as directed or approved by the Engineer.

1807 - DETOURS AND DIVERSIONS

1807.01 GENERAL

Detour works shall comprise but not be limited to necessary field surveys, the construction and maintenance of paved and unpaved Detour carriageways and shoulders including all earthworks, the provision and installation of metal beam guardrails, temporary concrete barriers, adequate drainage, lighting, traffic signals, signs, barricades, pavement markings and other traffic control devices as shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer. Where required, temporary protection of existing services, in accordance with the requirements of the concerned Service Authority or Company, shall form part of the Detour works.

Restoration of the Detour sites to their original condition or such other condition as directed or approved by the Engineer will be required on completion of use of the Detours.

Diversion works shall comprise, but not be limited to, the installation, maintenance and removal of traffic signs (including temporary illumination of the signs where required by the Drawings or directed by the

Engineer), traffic signals, and other traffic control devices indicating and controlling alternative routes on existing roads, as shown in the Contract Documents, or on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer, for use where an existing road is temporarily closed due to maintenace or construction work.

1807.02 DRAWINGS FOR DETOURS, DIVERSIONS AND TEMPORARY, TOTAL OR PARTIAL ROAD CLOSURES

1807.02.1 Traffic Detour and Diversion Drawings

The Traffic Detour and Diversion Drawings included in the Documents show the major road detours, diversions, road closures and traffic management schemes proposed for construction of the Works.

The Drawings have been approved by the Ministry of Public Works Roads Administration, Maintenance Department, the Ministry of the Interior General Traffic Department, the Traffic Studies Section of the Kuwait Municipality Planning Department, the Municipality Traffic Department and the Kuwait Public Transport Company. The Drawings for the major detours and diversions are suitable for submission to the appropriate Relevant Authorities to obtain permits to implement the major road detours and diversion proposals.

1807.02.2 Alternative Proposals

If the Contractor wishes to propose an alternative detour or diversion concept or significantly amend the alignment of the detour roads as indicated on the Traffic Detour Drawings he shall be entirely responsible for agreeing the revised concept with and for preparing detailed detour construction or diversion drawings (to the same degree of detail as those forming part of the Traffic Detour Drawings) for approval of the Engineer, the Relevant Authorities (as specified herein) and the Traffic Studies Section of the Kuwait Municipality Planning Department.

1807.02.3 Drawings for Sub-Stagings, Localised Detours and Temporary, Total or Partial Closure of Roads

The Contractor shall prepare any additional drawings required to show sub-stagings necessary to construct the major detours together with all drawings required to obtain permits for localised short term detours and temporary, total or partial closure of roads. The drawings shall be to a scale of 1:1000 and shall show the proposed highway geometry and the number, type and location of traffic control devices as specified in these Documents. Copies of the Contract Drawings may be used as the base for all such additional drawings.

1807.02.4 Vertical Alignment

The vertical profile for detour roads shown on the Traffic Detour Drawings is indicative of the alignment proposed. The Contractor shall review the proposed alignment and make such adjustments, necessary to maintain the required clearance to services and to ensure adequate road drainage.

1807.02.5 Detailed Detour Construction and Diversion Drawings

Drawings prepared by the Contractor for alternative detour and diversion schemes, and those for sub-stagings of major detours, minor detours or for temporary, total or partial closure of roads shall become detailed detour Construction drawings once approved by the Engineer and the appropriate Relevant Authorities.

The detailed detour Construction and diversion drawings shall be a part of the Contract Documents, provided that the approval of the drawings shall in no way release the Contractor from his responsibilities for the proper fulfillment of the requirements of the Contract. The Contractor shall provide the Engineer with one transparency on stable polyester film together with six (6) paper copies and one soft (CD) copy of each of the detailed detour Construction and Diversion drawings with the exception of those which have been nominated from the set of Traffic Detour and Diversion Drawings.

1807.03 GENERAL CONDITIONS TO BE OBSERVED FOR DETOURS AND DIVERSIONS

1807.03.1 Detours

General conditions for Detours shall include the following:

a. The flow of traffic shall be maintained at all times.

b. Traffic shall not be permitted to pass under bridges or other overhead structures which are under construction except with the approval of Engineer.

c. Detour roadway cross-sections and pavement structure sections shall be as detailed on the Drawings or as specified herein.

d. All Detour staging and sub-staging shall be approved by the Engineer in writing prior to commencing construction.

e. All traffic control and signing arrangements shall be in accordance with the requirements of these Specifications.

f. The Contractor shall ensure that the Detours are maintained at all times and that all necessary repairs are promptly carried out.

g. Pavement markings shall be re-applied when necessary as directed by the Engineer to maintain a high standard of definition throughout the period a Detour is in use.

1807.03.2 Diversions

General conditions for Diversions shall include the following:

a. The flow of traffic shall be maintained at all times.

b. The design of the diversion shall take into account the requirements of any load restrictions on bridges, culverts and other structures that may be considered as part of a diversion route.

c. All traffic control and signing arrangements shall be in accordance with the requirements of these Specifications. Temporary traffic signs shall be illuminated at night where shown on the Drawings or required by the Engineer.

1807.04 TYPES OF DETOURS AND DIVERSIONS

1807.04.1 General

The following types of Detours and Diversions shall be utilised as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

Type I Temporary Unsurfaced Detour (for one week period)

Type II Temporary Surfaced Detour (for one month period)

Type III Short Term Detour (for three months period)

Type IV Long Term Detour (for longer than three months period)

Type V Diversion using existing roads

1807.04.2 Type I – Temporary Unsurfaced Detour

The existing ground surface shall be graded and compacted to the satisfaction of the Engineer.

The Contractor shall ensure satisfactory dust control in accordance with Clause 1802.12 of these Specifications.

1807.04.3 Type II – Temporary Surfaced Detour

The surface of the Detour shall be prepared as noted for a Type I Detour and shall then be treated with a prime coat as described in Clause 405 of Section 4 (Asphalt Works) of these Specifications followed by a 50 mm thick layer of asphaltic concrete Type II laid and compacted in accordance with Section 4 (Asphalt Works) of these Specifications.

1807.04.4 Type III and Type IV Detours

The pavement construction details for both Type III Short Term and Type IV Long Term Detours will be as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

1807.04.5 Type V Diversion

The diversion shall utilize existing roads and shall follow the route and utilize the traffic signs layout and legends, traffic signals, and other traffic control devices indicating and controlling alternative routes on existing roads as shown on the Contract Drawings or directed by the Engineer/MOI. If the Contractor wishes to propose an alternative diversion concept or significantly amend the route of the diversion roads as indicated on the Drawings or directed by the Engineer/MOI, he shall be entirely responsible for agreeing the revised concept with, and for preparing detailed diversion drawings (to the same degree of detail as those forming part of the Traffic Diversion Drawings) for approval of, the Engineer, the Ministry of Interior's Traffic department, the Relevant Authorities (as specified herein) and the Traffic Studies Section of the Kuwait Municipality Planning Department.

1807.05 REQUIREMENTS FOR DETOURS AND DIVERSIONS

1807.05.1 General

The requirements of Clause 1802 Application of Traffic Control Devices of these Specifications as supplemented herein shall apply to Detour and Diversion Works.

1807.05.2 Construction Requirements

Earthworks shall be constructed as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer. Acceptable grades and grade transitions shall be provided where Detours join existing pavements.

The works shall be carried out in accordance with the following -Sections of these Specifications:

a Earthworks Section 2 (Earthworks)
b. Sub-Base Section 3 (Sub-Base and Base Course)
c Asphalt Works Section 4 (Asphalt Works)
d. Temporary Drainage Section 6 (Stormwater Drainage)

The requirements for Dynaflect testing of the earthworks (Clause 204.01.3) of Section 2, sub-base (Clause 303.03.7) of Section 3 and asphalt works (Clause 411.03.4) of Section 4 of these Specifications shall not apply to Detour Types I, II and III which do not form part of the Permanent Works.

1807.05.3 Temporary Lighting

1807.05.3.1 Detours

The Detour lighting system shall be as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer. Unless otherwise specified, the Contractor shall install light standards at approximately 40 m spacings in the median and/or on one or both sides of the Detours.

1807.05.3.2 Diversions

Any additional temporary lighting required on a Diversion route shall be as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

1807.05.3.3 Signs

Where shown on the Drawings or required by the Engineer, temporary Detour and Diversion traffic signs shall be illuminated to the approval of the Engineer.

1807.05.4 Cross Drainage

The Contractor shall ensure the continuity of existing cross-drainage facilities by extending them under Detours as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

Cross-drainage shall be provided under Detours in locations approved or as directed by the Engineer.

Unless otherwise shown on the Drawing or in the Contract Documents or unless otherwise directed by the Engineer the extension of existing cross-drainage facilities and the provision of cross-drainage under Detours shall be by 1000 mm diameter reinforced concrete pipes as specified in Section 6 (Stormwater Drainage) of these Specifications.

Where specified or as directed by the Engineer drainage pipes shall be recovered, cleaned and set aside for reuse on other Detours. Used pipes shall not be used in the permanent works.

1807.05.5 Restoration of Detour Sites

On completion of the Works or when, in the opinion of the Engineer, the Detours are no longer required, the Contractor shall remove all temporary lighting, and all construction, materials, and structures as specified in Clause 1802 of these Specifications, and shall restore the Detour sites to their original condition, or to such other condition as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

1807.05.6 Restoration of Diversions

On completion of the Works or when, in the opinion of the Engineer, the Diversions are no longer required, the Contractor shall remove any temporary lighting and all temporary traffic signs, temporary traffic signals, other temporary traffic control devices, as specified in Clause 1802 of these Specifications, and shall restore the Diversion Roads to their original condition, or to such other condition as shown in the Contract Documents, on proposals submitted by the Contractor and approved by the Engineer or as directed by the Engineer.

1808 - PORTABLE ENERGY ABSORBING TERMINAL (E.A.T.) SYSTEMS

The portable E.A.T. systems are to be used as shown in the Drawings in connection with the maintenance and protection of traffic during the various construction stages.

The materials, installation, spare parts, repair of damaged E.A.T. systems and all requirements for the E.A.T. system will be provided in accordance with Clause 1206 of Section 12 (Metalworks) of these Specifications.

Where indicated on the Drawings and when directed by the Engineer, the Contractor shall relocate such portable E.A.T. systems. The relocation shall include the complete portable E.A.T. system with all anchors.

When no longer required for the maintenance and protection of traffic during construction, the Contractor shall remove all portable E.A.T. systems, which shall become the property of the Employer, and shall load, transport, unload and place them in storage at a location directed by the Engineer.

1809 - MEASUREMENT AND PAYMENT FOR MAINTENANCE AND PROTECTION OF TRAFFIC

1809.01 MEASUREMENT

Measurement shall be as follows:

1809.01.1 Construction Signs and Vertical Panels

Construction signs and vertical panels shall each be measured by square metre of face area of each type for each time they are initially used in an area or locality, as shown in the Contract Documents, or as proposed by the Contractor and approved by the Engineer, or as directed by the Engineer.

1809.01.2 Barricades, Cones and Drums

Barricades, Cones and Drums shall each be enumerated separately for each type for each time they are initially used in an area or locality, as shown in the Contract Documents, or as proposed by the Contractor and approved by the Engineer, or as directed by the Engineer.

1809.01.3 Temporary Metal Beam Guardrail

Temporary Metal Beam Guardrail shall be measured by the metre run (centre of end post to centre of end post). Measurement shall be for:

a. as provided and installed.
b. as provided and installed as replacement to damaged rail.
c. as removed and re-installed.

1809.01.4 Temporary Concrete Barriers

Temporary Concrete Barriers shall be measured by the metre run. Measurement shall be for:

a. as provided by Contractor and installed.
b. as provided by MPW and installed.
c. as provided by Contractor and installed as replacement to damaged barriers.
d. as provided by MPW and installed as replacement to damaged barriers.
e. as removed and re-installed.

1809.01.5 Warning Lights

Warning lights type A, B or C shall be measured separately by the actual number of each type for each time they are initially used in an area or locality as shown in the Contract Documents, or as proposed by the Contractor and approved by the Engineer or as directed by the Engineer.

1809.01.6 Flashing Arrow Boards

Flashing Arrow Boards shall be measured by unit on a daily basis for any portion of a day for which they were ordered by the Engineer and were actually operational on the Works.

1809.01.7 Temporary Traffic Markings

Temporary Traffic markings shall be measured as specified in Clause 701. 16 (Measurement and Payment of Road Markings) of Section 7 (Traffic Marking and Signs) of these Specifications for each type of material used. Measurement shall be for:

a. application
b. removal
c. re-application

1809.01.8 Raised Pavement Markers

Raised Pavement Markers shall be measured by the number installed, removed, or reinstalled. Measurement shall be for:

a. Non reflective markers
b. Reflective markers (regardless of colour combination)
c. Type d markers

1809.01.9 Temporary Lighting

Temporary Lighting shall be measured by the number of single-arm and the number of double-arm standards installed. Measurement shall be for:

a. single-arm standards as installed (Ministry of Electricity and Water provided)
b. single-arm standards as installed (Contractor provided)
c. double-arm standards as installed (Ministry of Electricity and Water provided)
d. double-arm standards as installed (Contractor provided)
e. single-arm standards as installed as replacement to damaged standards (Ministry of Electricity and Waterprovided).
f. single-arm standards as installed as replacement to damaged standards (Contractor provided).
g. double-arm standards as installed as replacement to damaged standards (Ministry of Electricity and Water provided)
h. double-arm standards as installed as replacement to damaged standards (Contractor provided)
i. removal and reinstallation of single arm standards.
J removal and reinstallation of double arm standards.

1809.01.10 Temporary Traffic Signals

Temporary Traffic Signal installations shall be measured as an item for each junction to include installation, maintenance, and removal.

1809.01.11 Dust Control

Dust Control shall be measured and paid for separately for Detours only. Measurement shall be by the number of 1000 litre units of water used as approved by the Engineer.

1809.01.12 Flagmen

When required, flagmen shall not be measured and paid for separately but shall be considered a subsidiary obligation of the Contractor under other items of this Section.

1809.01.13 Maintenance of Access

Except for measurement and payment of items included in Section 18 (Maintenance and Protection of Traffic) of these Specifications, maintenance of access shall not be measured and paid for separately but will be considered a subsidiary obligation of the Contractor under other items of this Section.

1809.01.14 Detours and Diversions

Measurement of temporary unsurfaced detours shall be by the metre square of carriageway as defined in the Contract and/or as instructed by the Engineer.

Measurement of temporary paved detours shall be by the metre square of the top of the paved surface for the types specified. Tapered edges of the paved surfaces shall not be included in the measurement. Measurement of Diversions will be by the unit, per Diversion including setting up, maintenance, and removal of all signs, temporary lighting, temporary signals and everything else necessary for the safe operation of the diversion, for any length of time of diversion. Measurement shall be for:

a. Type I Temporary Unsurfaced Detour
b. Type II Temporary Surfaced Detour
c. Type III Short Term Detour
d. Type IV Long Term Detour
e. Type V Diversion

The construction of other detours and access roads required but not shown in the Contract Documents shall not be measured but shall be considered as subsidiary to other items of work.

1809.01.15 Cross-Drainage

Cross drainage pipes shall be measured by the overall metre run of each pipe diameter regardless of depth for both the initial installation and for re-use.

1809.01.16 Maintenance of Detours and Diversions

The cost for maintaining the detours and diversions, including such items but not limited to metal beam guardrails, temporary concrete barriers, flashing arrow boards, raised pavement markers, temporary lighting, temporary traffic signals, temporary signage, detour pavement, earthworks and shoulders and drainage shall not be measured or paid for separately but shall be considered a subsidiary obligation of the Contractor under other items of this Section.

1809.01.17 Restoration of Detour and Diversion Sites

Restoration of Detour sites shall not be measured and paid for separately but will be considered a subsidiary obligation of the Contractor under other items of this Section.

1809.01.18 Contractor's Traffic Safety Supervisor

The Contractor's Traffic Safety Supervisor, communications equipments, and night time construction lighting system will not be measured or paid for but will be considered a subsidiary obligation of the Contractor under other items of this Section.

1809.01.19 Portable Energy Absorbing Terminal (E.A.T.) Systems

Measurement shall be by the number for each type required as provided and installed or as removed and reinstalled.

No separate measurement or payment will be made for repair of E.A.T. systems damaged by any cause whatsoever, the cost of which shall be considered a subsidiary obligation of the Contractor under other items of this Section.

No separate measurement or payment will be made by the Employer for the removal, loading, transporting, off-loading and placing portable E.A.T. systems in the MPW stores when no longer required and when directed by the Engineer.

1809.02 PAYMENT

1809.02.1 General

The quantities, as determined in accordance with Clause 1809.01of these Specifications, will be paid for at the rate per unit of measurement for each of the pay items included in the Bills of Quantities, which payment will be full compensation for all works and requirements prescribed in this Section of these Specifications.

No traffic control devices that are delivered to or removed from the Site without approval of the Engineer will be considered for payment.

1809.02.2 Construction Signs, Vertical Panels, Barricades, Cones, Drums and Warning Lights

Rates for Construction Signs, Vertical Panels, Barricades, Cones, Drums and Warning Lights etc. shall also include for, but not be limited to: supply, installation, loading and unloading, positioning and repositioning within an area or locality, transporting, storage and removal on completion, and all fixings, posts, temporary foundations, ballast, regular cleaning, maintenance, replacement of lost, stolen, damaged or defective items, and all associated labour, material and equipment requirements.

1809.02.3 Temporary Lighting

Rates for Temporary Lighting shall also include, but not by way of limitation, any necessary generators with fuel, spares and maintenance, lamps and cut-outs for standards supplied by the Ministry of Electricity and Water and replacement lamps as and when required for all standards.

1809.02.4 Temporary Traffic Signals

Rates for the Temporary Traffic Signal installation for each particular junction shall also include for, but not be limited to, repositioning existing equipment, supplying, installing and reinstalling additional equipment including all cabling, ductwork, controller foundations and the like to maintain an approved traffic signal installation until such time as the permanent signal installation is operational. Rates shall also include for removal of all existing and temporary equipment and all such other works as are required in accordance with the Contract Documents to maintain the approved signal control system for all detour and traffic management stages at the particular junction.

1809.02.5 Detours

In addition to the requirements of Clause 1809.02.1 herein, payment for Detours shall also include for necessary field surveys, preparation of Construction drawings, liaison and gaining approvals from the Engineer/MOI and the Relevant Authorities and all other things necessary to provide the Detours. Payment shall also include for the recovery and stockpiling of all asphaltic materials as specified.

No claim for additional costs or extension of time will be allowed consequent to approval of alternative layouts for Detours proposed by the Contractor.

1809.02.6 Portable Energy Absorbing Terminal (E.A.T.) Systems

Payment for provision and installation of portable E.A.T. systems shall be at the rates in Section 18 of the Bills of Quantities which rates shall include for detailed design submission, supply and installation of the complete system (including all necessary materials and anchor systems), labour, tools, equipment and appurtenances and for supplying installation and maintenance manuals to the Engineer as specified herein.

Payment for removal and reinstallation of portable E.A.T. systems from one location to another within the limits of this Contract shall be at the rates shown in the Bills of Quantities, which rates shall include for all materials, labour, tools, equipment, loading, hauling, unloading and appurtenances required to remove and reinstall the portable E.A.T. system, complete, in a new location as shown on the approved drawings or as directed by the Engineer.

1809.03 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1809.1	Construction Signs	sq.m
1809.2	Vertical Panels	sq.m
1809.3	Barricades	nr
1809.4	Cones	nr.
1809.5	Drums	nr
1809.6	Flashing Arrow Boards	nr/Days
1809.7	Temporary Thermoplastic Broken and Solid Lines Traffic Markings (width) (color) (application / removal/reapplication)	m
1809.8	Temporary Reflectorised Broken and solid linesTraffic Markings (width) (color) (application / removal /reapplication)	m
1809.9	Temporary Tape Markings (width)	m
1809.10	Raised Pavement Markers (type, installed/removed/reinstalled)	nr
1809.11	Temporary Metal beam Guardrail (provided & installed/ provided & installed as replacement/ removed and re-installed)	m
1809.12	Temporary Concrete Barrier (provide by the Contractor/ provided by MPW/provided by the Contractor as replacement/ provided by MPW as replacement/ removed and re-installed)	m
1809.13	Warning Lights (Per Type)	nr
1809.14	Temporary Lighting (Per Type) (provided by the Contractor/ provided by MEW/ provided by the Contractor as replacement/ provided by MEW as replacement/ removal and reinstallation)	nr
1809.15	Temporary Traffic Signal (Per Junction)	L S
1809.16	Detours (Per Type)	sq.m
1809.17	Diversions	nr
1809.18	Dust Control (For Detours Only)	cu.m
1809.19	Cross-Drainage (pipe dia./ initial installation/re-use)	m
1809.20	Portable EAT Systems (Per Type) (provided and installed/ removed and reinstalled)	nr

SECTION 19: TIMBER STRUCTURES

1900 - GENERAL

1900.01 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

B 766 Electrodeposited Coatings of Cadmium

AASHTO

AASHTO LRFD Bridge Construction Specifications
M 111 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
M 133 Preservatives and Pressure Treatment Process for Timber
M 168 Wood Products
M 232 Zinc Coating (Hot Dip) on Iron and Steel Hardware
M 299 Coatings of Cadmium Mechanically Deposited

AWPA

Standards C1 & C14 Pentachlorophenol Timber Treatment

1900.02 UNTREATED STRUCTURAL TIMBER AND LUMBER

Untreated structural timber, lumber, and piling shall conform to the requirements of AASHTO M168.

No boxed heart-pieces shall be used in outside stringers, floor beams, caps, posts, sills or rail posts. Boxed heart-pieces are defined as timber so sawed that at any point in the length of a sawed piece the pith lies entirely inside the four faces.

Yard lumber shall be of the kinds and grade called for on the Drawings. Round poles and posts shall be of the kinds indicated on the Drawings.

1900.03 TREATED STRUCTURAL TIMBER AND LUMBER

Treated structural timber, lumber, and piling to be treated shall conform to the requirements of AASHTO M168 and M133. The type of treatment to be used will be shown on the Drawings or in the Contract Documents and shall conform to the applicable requirements of AWPA Standards C1 and C14.

1900.04 HARDWARE

Machine bolts, driftbolts, and dowels shall be medium steel. Washers shall be cast ogee gray iron castings or malleable castings, unless washers cut from medium steel are indicated on the Drawings.

Bolts shall have square heads and nuts, unless otherwise specified. Nails shall be cut or round nails of standard form. Spikes shall be cut or round spikes or boat spikes as specified.

All hardware shall be galvanized in conformity with AASHTO M 232 or cadmium plated in conformity with AASHTO M 299. All steel components, timber connectors, and castings, other than malleable iron, shall be galvanized in accordance with AASHTO M 111.

Split ring or shear plate timber connectors shall be of approved design conforming to the requirements of Article 16.2.6 AASHTO LRFD Bridge Construction Specifications.

1900.05 MEASUREMENT AND PAYMENT

1900.05.1 Method of Measurement and Basis of Payment

Measurements of lumber and timber shall be computed from the nominal dimensions and actual lengths. The cross-sectional dimensions in the Drawings shall be interpreted as standard sizes.

Measurements for glue laminated girders and beams shall be computed from the applicable finished dimensions and actual lengths. Quantities for glue laminated girders and beams shall be paid by the linear meter for each size and stress combination.

The measurement of lumber and timber and of glue laminated girders and beams shall include only such material as is part of the completed and accepted work, and shall not include materials used for erection purposes, such as falsework, bracing, and sheeting.

The quantities to be paid for shall be the number cubic meters of each species and grade of lumber and timber complete in place and accepted.

Payment for timber, lumber and glue laminated girders and beams shall be considered to be full compensation for all costs of furnishing of materials, treatment, equipment, tools and labor for the fabrication, erection, and painting necessary to complete all of the work in a satisfactory manner.

1900.05.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
1900.1	Lumber or timber (species and grade)	cu.m
1900.2	Glue Laminated Girders or Beams (size and stress combination)	m

SECTION 20: GAS PIPELINE CONSTRUCTION

2000 - GENERAL REQUIREMENTS

2000.01 DRAWINGS AND SPECIFICATIONS

Unless otherwise shown on the Drawings or in the Contract Documents, the latest issue of the Standard Drawings and Specifications of the Kuwait Oil Company shall apply to work carried out under this Section.

NOTE: The Contractor shall be responsible for liaison with the Kuwait Oil Company and for all costs incurred in obtaining the latest versions of the above Specifications and Drawings and for ensuring that work and materials comply with the relevant parts of those Specifications and Drawings.

SECTION 21: TELEPHONE WORKS

2100 - GENERAL

2100.01 SCOPE

This Technical Specification and the Ministry of Communications (MOC) Standards for Materials, covers supply of materials and installation of the various items of work required in connection with the construction of civil works for the Telephone Network Department of the MOC. These works include lying of ducts / pipes and construction of Manholes (MH) and Hand holes (HH) and associated works.

The following MOC Standards also form part of this specification

(a)	G20:l0:00l:22	Hardware for use in MH & HH.
(b)	G20:l0:00l:23	Manhole and handhole Covers.
(c)	G20:l0:00l:32	uPVC Ducts, Bends, Couplings, Duct Bonding Materials and Spacers.
(d)	G20:l0:00l:33	Materials for Civil Work.
(e)	G20:l0:00l:34	Galvanized Ducts and Troughs.

The Contractor shall be required to carry out necessary field surveys, via accurate field measurements (including level measurements), acquaintance of the route, verification of existing services by digging Pilot holes, and make drawings present accurately all details by correcting incongruities with the drawings and/or making necessary supplement, as well as other necessary drawings, prepare details and submit them for the approval of MOC / Engineer approval. After obtaining the approval of MOC / Engineer, the Contractor will proceed with execution.

The Contractor has to submit design (where required), shop and as built drawings for approval of MOC / Engineer

In case necessity arises for making on-the-spot corrections and changes in Drawings during certain phases of the construction work, the MOC / Engineer will not issue revised Drawings to the Contractor. When changes are made, dated and initialed by the MOC / Engineer in one of the Contractor's drawings, it shall be Contractor's responsibility to incorporate the corrections in all other relevant drawings in his possession.

All documents, including drawings to be submitted by the Contractor, must be prepared in quadruplicate.

2100.01.1 Definitions

"MOC" means Ministry of Communications

"Engineer" means as that defined in the General Conditions of Contract

"Engineer's representative" means as that defined in the General Conditions of Contract

"Employer" means as that defined in the General Conditions of Contract

2100.02 NORMATIVE REFERENCES

The following standards are referred to in the text as provision documents. At the time of publication, the mentioned standards are all valid. However, all standards are subject to revision.

(a) BS 882: Specification for aggregates from natural sources for concrete
(b) BS 410: Test Sieves - technical requirements and testing
(c) BS EN 1881: Products and systems for the protection and repair of concrete structures
(d) BS 21: 1985 Specification for pipe threads for tubes and fittings
(e) BS EN ISO 6507-1: 2005 Metallic materials. Vickers hardness test.
(f) BS 812-124:2009 Testing aggregates. Method for determination of frost heave
(g) DIN 16970: Adhesives for bonding pipes and pipe system elements of rigid PVC
(h) BSI BS 3416: Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water-AMD 7288: September 15, 1992

(i) BS EN 14814-2007: Adhesives for thermoplastic piping systems for fluids under pressure specifications.
(j) BS 4340: HR Steel for general engineering purposes
(k) ASTM C150: Standard Specification for Portland Cement

2100.03 CONTENTS OF THE SPECIFICATION

This Specification consists of installation specifications, materials specifications, drawings, etc. The MOC Standards as revised from time to time are also considered to form part of this Specification. Ministry of Communications reserves the right to make amendments to the Specifications and working practices during the Contract Execution period. No claim shall be made for minor amendments which shall be complied by the Contractor.

The Contractor is expected to provide for all necessary associated materials, even if they are not stipulated in the Specification. The unit rate quoted for each item should include all accessories & allied works and no separate claim shall be acceptable for such items required during execution of work.

2101 - CIVIL WORK INSTALLATION

2101.01 CIVIL WORKS INSTALLATION MATERIALS

2101.01.1 Cement

Cement to be used shall be sulphate resisting type 5.

The cement shall meet the requirements shown in MOC Standard G20:l0:00l:33 and satisfy the tests contained in ASTM C-150.

Cement with appearances of setting even to a limited extent shall not be used.

The cement to be used for construction work must be brought in sealed branded bags and stored in a proper manner.

2101.01.2 Sand

Sand should be clean, sharp, gritty and free from loam, organic matter or adherent coatings and should conform to BS 410, 812, 882 and MOC Standard G20:l0:00l:33. Sand, which on being shaken with water in a graduated glass and allowed to settle, shows a layer of silt greater than 5% is unsuitable and will be rejected. Sand for concrete should be well grained, the grains varying in size up to 2.36 mm maximum.

2101.01.3 Aggregate

The aggregate for concrete should be clean screened ballast, gravel or stone conforming to BS 410, 812 and 882. The material should be in the form of cubes or spheres (not flakes), and should be uniformly graded from 2 centimeters upwards to the maximum size of 4 cm. It should be free from dirt, floury stone dust, loam and earth or other like materials. Clinker, brick, sandstone or other porous stones should not be used.

2101.01.4 Water

Only water from the potable supply system of Kuwait may be used.

For curing or washing aggregate, the water used shall not contain vegetable matter, acids, excessive phosphates or other salts in such quantities as to cause efflorescence on the face of the concrete or adversely affect the setting time.

2101.01.5 Concrete Mixes

The grades of concrete to be used in construction shall be as specified in Section 5 “Concrete Works”

Concrete Class K-140 shall be used for all non-structural concrete works.
Concrete Class K-300 shall be used for all structural concrete works.

2101.01.6 Mortar

Mortar for cement blocks shall be of 1:3 mix of cement and sand.

The materials, after being gauged, shall be thoroughly mixed in a dry state on a non-absorbent base and then worked up with sufficient sweet water, applied through a hose or sprinkler to form a stiff paste. Mortar once mixed shall be promptly used before the initial setting takes place, i.e. it must be used within one hour of mixing. Where mortar is not used within this time, the materials should be discarded. The addition of fresh material to restore stiffness to sloppy mortar or the addition of water after setting has commenced is not permissible.

The mortared joints shall be kept continuously damp for at least 2 days.

2101.01.7 Cement Blocks

The cement blocks shall be used only in case of repair of existing Block type Manholes or Handholes and all new MHs and HHs constructed shall be reinforced type.

Cement blocks shall be solid and of first quality to the specifications of Kuwait Government, Ministry of Public Works, made in vibrating pressure machines and thoroughly cured. All blocks shall be for bearing walls and when tested according to B.S. Standard or Kuwait Standards have minimum compressive strength of 50 Kg/Cm^2 and average value of compressive strength for 12 blocks shall not be less than 60 Kg/Cm^2 after 28 days of casting. The blocks shall be hard, sound and clean with sharp well defined edges and of dimensions required for the work. The blocks shall be presoaked for a minimum of 4 hours immediately prior to use.

The MOC’s Supervising Officer / Engineer may at his discretion, send samples of blocks proposed to be used for inspection and test by the Kuwait Government Testing Station. Work shall not normally be delayed for the result of the tests to be ascertained but should blocks prove unsatisfactory under test, the unused portion of the consignment will be rejected. The MOC / Engineer will have the right to either reject any work on which the particular blocks of unsatisfactory quality have been used or require from the Contractor an indemnity against any loss which may be incurred from imperfection of the work which may show up subsequently.

2101.01.8 Reinforcing Bars

All reinforcing bars used shall comply with the requirements described in Section 5 “Concrete Works”.

2101.01.9 Iron works and fittings in Manholes and Handholes

All iron works used in manhole, handhole etc. shall conform to MOC Standard G20:l0:00l:22. Mild steel anchor irons, cable racks and support, ladder and other iron required for manhole, handhole, etc. shall conform to B.S. 4360 or equivalent and be in accordance with the MOC Drawing TX368/1, TX-483.

Manhole and Handhole Covers:

Manhole Covers are of medium duty cast iron. Handhole Covers are hinged type of medium duty ductile iron. Each complete manhole cover shall consist of the cover and its frame. Each complete handhole cover shall consist of two pieces called the upper cover and lower cover and its frame. The manhole and handhole Covers shall conform with MOC Standard G20:l0:00l:23. and MOC Drawings shown below

Manhole Covers & Frames	TX: 481
Handhole Covers & Frames	TX: 482A

In the case of Key hole the following dimensions are permissible:

Specified	Acceptable to MOC.
15 mm.	14 to 16 mm.
30 mm.	29.5 to 33 mm

2101.01.10 Formwork for Concrete

The Contractor shall be responsible for the supply, design, erection, stability, striking and removal of any formwork and centering required so as to preserve the concrete from damage or distortion during setting. The form work shall be of such quality and strength as will ensure complete rigidity during placing, ramming, setting and curing of concrete. Removal of forms shall not begin until the concrete has either obtained the percentage of the 28 day design strength or until after the period shown below, unless otherwise authorized by the MOC / Engineer:

False work supporting

Slabs or beams	7 days	80%
Walls	1 day	70%

The MOC / Engineer shall be informed in advance when the Contractor intends to strike any form work.

All new-placed concrete shall be cured and curing shall begin immediately after removal of form work and shall be continued throughout any finishing processes and for at least seven days.

Any work that causes loading of manhole and passage of traffic can start after concrete has required design strength.

Concrete Finishes

On completion of RCC manhole/handhole, the floor shall be rendered with cement mortar in accordance with relevant Drawings. The walls of concrete manhole shall have a smooth finish, any slight cavities exposed when the shuttering is removed shall be made good with cement mortar and any projections removed. Under no circumstances shall the walls be coated with a cement or cement/sand wash or mortar rendering/plastering.

Finally inside the neck, soffit roof slab and top side of the wall shall be cleaned using a suitable water soluble detergent followed by a clean water rinse to remove shuttering oil. Water shall be wiped off with a clean cotton rag and the prepared surfaces shall then be painted with one coat of a white paint approved by MOC. Mixing and application of the paint, shall be strictly in accordance with the manufacturer's instructions.

2101.01.11 Bitumen

Bitumen used should conform to B.S. 3416 Type-1 or equivalent.

2101.01.12 Unplasticised P.V.C. Ducts / pipes

Unplasticised PVC ducts / pipes and Spacers shall conform with MOC Standard G20:l0:001:32.

When uPVC ducts / pipes are procured, the Contractor shall make a thorough examination to ensure that the ducts / pipes are undamaged. Damaged ducts / pipes shall be rejected and promptly removed from site of works.

When bends are used at curved positions, the materials of the uPVC bends proposed shall be in conformity with MOC Specifications for ducts / pipes and prior approval from MOC / Engineer shall be obtained for sample of bends.

uPVC Ducts / pipes for MH and HH Route

The uPVC ducts / pipes shall be supplied in 6 meter lengths. The ducts / pipes laid in manhole/handhole routes shall have minimum 100 mm internal diameter and minimum 4.5 mm wall thickness. The uPVC ducts / pipes shall have one end plain and the other end a 100 mm expanded socket for spigot coupling. The expanded end shall have a wall thickness not less than that specified for the duct / pipe, and the tolerance on the fit of the spigot and socket shall be compatible with the requirements for jointing specified herein. Suitable couplers shall be used for jointing uPVC

ducts / pipes with steel ducts / pipes when required and the sample of these couplers shall be approved by MOC / Engineer
The spigot end of each duct / pipe shall be indelibly marked with a continuous circumferential black line 100 mm from the end of the duct / pipe. This line shall be used as a measure of the penetration of the spigot into the socket of the adjoining duct / pipe. Joints which show, in the opinion of the MOC Engineer, inadequate penetration may be rejected. Manufacturer's name and year of manufacture shall be clearly marked on the duct / pipe.

Pre-made slow bends of 100 mm dia., uPVC pipe shall be in full conformity with the material specification and dimensional details shown in Figure I (G20:10:001:32). A 90 mm dia. x 300 mm long mandrel shall pass through this bend. Sample shall require due approval from MOC / Engineer.

uPVC Ducts / pipes for Lead-in

The ducts / pipes shall be supplied in 4 meters lengths. The ducts / pipes shall have a minimum 3 mm wall thickness and external diameter of 50 mm.

The ducts / pipes shall be jointed using the method of spigot and socket couplings and cement solvent. The coupling for jointing with G.I. duct / pipe shall be made of uPVC and have one end threaded, and the other end shall be sealed with solvent cement. Suitable reducing couplers shall be used for jointing 50 mm uPVC ducts / pipes with subscriber's duct / pipe of different sizes. The manufacturer's name and year of manufacture shall be marked on each duct / pipe.

Pre-made 90 degree long bends of 50 mm uPVC pipe shall be in full conformity with the material specification and its dimensional details shown on Figure 2 (G20:10:00l:32). Sample shall require due approval from MOC / Engineer.

2101.01.13 Storage of uPVC Ducts / pipes

Unless otherwise approved by the MOC / Engineer, uPVC ducts / pipes shall be stacked in accordance with the manufacturer's instructions and in inside storage. Where outside storage is approved the ducts / pipes shall be supported at least 300 mm above ground on suitable bases spaced to avoid bending of the ducts / pipes. The ducts / pipes shall not be stacked to more than 10 layers height and be covered with impermeable sheets and secured with ropes to avoid movement. The ducts / pipes shall be stored in~ the shade at all times.

2101.01.14 Cement Solvent

All joints for uPVC ducts / pipes are to be made with cement solvent conforming to MOC Standard G20:l0:001:32.

The number of joints that can be made with one kg of solvent and one kg of cleanser shall be indicated. Shelf life and any special precaution to be taken during use must be clearly stated. Solvent cement and cleanser shall be packed in airtight tins of 1 kg and 0.5 kg respectively. The Contractor shall submit the test result of shear strength and long term hydrostatic pressure for the approval of the MOC / Engineer.

2101.01.15 Asbestos Cement Ducts / pipes

No asbestos cement ducts / pipes are permitted to be used in any of the works.

Existing asbestos cement ducts / pipes which are required to be replaced or redundant, shall be carefully broken, wrapped in polythene sheeting, transported to designated sites and disposed of in a manner recommended and approved by the Environmental Protection Agency. No additional payment will be made to the Contractor for this special method of disposal.

2101.01.16 Steel Ducts / pipes

The steel ducts / pipes shall conform with MOC Standard G20:10:001:34. Steel ducts / pipes for MH and HH route shall be of 100 mm internal diameter.

The ducts / pipes shall be supplied in 6 metre lengths.

The wall thickness of the 100 mm G.I. duct shall be 5.4 mm.

Threaded coupling shall be used for jointing two lengths and the joints shall be made water tight by applying white lead pigment. The ducts / pipes shall be given two coats of an approved first quality anticorrosive paint.

For Service ducts / pipes used for lead-in from handhole/manhole to building/compound wall, the Steel ducts / pipes, accessories and couplings used for service ducts / pipes (lead-in) or for coupling with P.V.C. lead-in ducts / pipes for use in exposed portions shall be medium duty, seamless, galvanized steel ducts / pipes of 40/50 mm nominal bores and 3.25/3.65 mm wall thickness conforming to MOC Standard G20:l0:001:34 and the International Standards referred therein.

2101.01.17 Draw Box

The size of the Draw Box to be fixed at the end of lead-in duct / pipe will be 300 x 300 x 75 mm.

Draw Box is referred to in MOC Drawing No. TX-483. Draw Box and accessories shall be of best quality, galvanized steel, conforming to BS 21 and BS EN ISO 6507-1.

The cover shall be hinged to the body and shall be locked with a triangular head key and/or as approved by MOC.

Cable clamps shall be provided inside the box to keep the cable in position.

2101.01.18 Spacers for uPVC Ducts / pipes

The Spacers shall conform with MOC Standard G20:10:001:32 Clause 4-10. Samples of spacers are to be submitted to MOC / Engineer for approval before use.

2101.02 EXCAVATION

Excavation by hand or mechanical aids shall be carried out down to the required level by the Contractor in all types of surfaces, soils and rocks in any part of Kuwait.

The Contractor shall normally carry out the excavation in Telephone Plant reservation under sidewalks indicated in the Contract Drawings.

The Contractor shall support the sides of the trench with timber or other materials, where the depths of the trench, nature of soil or proximity of other services make this necessary. The Contractor cannot claim additional payments for any extra quantity of excavations that is necessitated by his failure to provide adequate timbering or due to the need for laying ducts / pipes or constructing manholes with additional depth. No separate payment will be paid for sheeting, bracing etc.

The Contractor shall dig pilot holes at his cost to confirm the location of existing services before he commences his works in an area where existing services of MOC and third party might exist.

Great care shall be taken by the Contractor to avoid undermining or otherwise disturbing the ducts / pipes, cables and installation. If despite precautions, such soil is disturbed, the plant concerned shall be temporarily supported and the void filled with a concrete mixture of K-140.

The Contractor shall protect and/or transfer, if necessary, all MOC and other existing services in a manner approved by the concerned Ministry and in accordance with the instructions of the MOC / Engineer, at Contractor’s expense.

The Contractor shall keep all excavations clear of water during laying of ducts / pipes or cables, installation of manholes and handholes and joints. He shall install well point system if required. No separate payment will be made for water removal.

The line of trench shall be kept as straight as possible. Where a change in direction is indicated between manholes or handholes, the trench shall be excavated so as to provide as large radius as possible, unless otherwise noted in the Drawing.

In no case shall the width of trench excavation be greater than is necessary for the satisfactory execution of work. The width of the trench beneath the surface shall never exceed the width at the surface.

The Contractor shall be solely responsible for settling all claims, damages and other suits arising from his work, and the MOC / Employer or the Engineer shall neither be involved nor held responsible for settling such claims.

2101.03 DEPTH OF TRENCHES

In case of installing numbers of ducts / pipes of less than maximum capacity for the type of MH, the lowest duct / pipe shall be laid at 40 cm from the base of manhole, so that standard depth may be ensured for future expansion

(a) Standard Depth of Trench for Manhole Route

The depth below the surface to the top of the uppermost ducts / pipes shall be 0.80 Meter or more.

(b) Standard Depth of Trench for Handhole Route

The depth below the surface to the top of uppermost ducts / pipes shall be 0.6 Meter or more.

(c) In case of direct buried cables the depth below the surface to the top of the cable shall be 1 Meter or more.

(d) Lead-in Duct / pipe

The depth below the surface to the top of the lead-in duct / pipe shall be 0.4 Meter or more.

(e) In case that these routes cross the carriageway, the depth below the surface shall be 0.2 Meter extra.

(f) In case the depth of laying of ducts / pipes is likely to be different from standard depth due to the presence of buried facilities or other reasons, the Contractor should submit the longitudinal profile drawings of the proposed duct / pipe route showing the location, elevation and size etc. of all other buried facilities including MOC ducts / pipes and manholes to the MOC / Engineer for approval.

(g) Meaning of "SURFACE" in the above context :

The "Surface" appearing in the context of the foregoing sub- paragraphs means the level of horizontal extension of the kerb top in case of footways and the centre of the asphalted road in case of carriageways.

Where a MH/HH has to be connected with a carriageway crossing, all depths are to be related to the depths of its carriageway crossing, and be not less than the standard construction dimension.

Where the surface of the ground is uneven; the trench shall be dug to a greater depth so that the ducts / pipes or cables shall not undulate like the surface. Any grading of level, such as, is necessary at road crossings or in passing from sidewalk to carriageway and vice versa or where ducts / pipes have to enter manholes, handholes or in any other circumstances, shall be gradual as the MOC / Engineer may direct. The MOC / Engineer may also require the Contractor to lay ducts / pipes in depths other than the Standard Depths given above.

2101.04 OUTSIDE PLANT DESIGN CONSIDERATIONS

The outside plant (OSP) design, to be carried out in consultation with MOC, should select routes in a way that precludes the need for future pathway relocation while taking into consideration factors like: safety, topography, local restrictions, and cost.

Right of way permits should be obtained from the appropriate authority for the use of the proposed infrastructure routes. The Contractor shall normally carry out the excavation in Telephone Plant reservation under sidewalks especially if the construction precedes the laying of the sidewalk.

For bridge crossings, ducts / pipes shall be installed on bridges when there are no other choices; approval of the concerned authority should be obtained. Ducts / pipes should be in steel for the bridge crossing either through walkways or through the main body of the bridge.

2101.05 LAYING OF DUCTS / PIPES

In general, uPVC ducts / pipes shall be used for all ducts / pipes laying works except where sufficient depth below the surface is not practicable, the Contractor shall then lay steel ducts / pipes after obtaining the approval of MOC / Engineer.

The Contractor shall use uPVC ducts / pipes in accordance with the design Drawings and instruction of the MOC / Engineer.

The duct configuration must be based on the standards given in MOC Drawing No. TX: 347/4/D-l & TX: 347/4/D-lA.

The Contractor shall propose to the MOC / Engineer, the expansion method after performing detailed field survey.

When proposing the expansion method, studies on the number of ducts / pipes in expansion and existing ducts / pipes, depth and arrangements of existing ducts / pipes, laying status of existing cable, road reservation as well as construction method shall be duly taken into consideration.

Consideration shall also be made as to the shift of existing ducts / pipes and re-arrangement of duct / pipe position.

Where required by MOC / Engineer, the Contractor has to lay new ducts / pipes instead of existing ducts / pipes which are to be abandoned. The Contractor shall make all necessary termination arrangements and seal abandoned ducts / pipes by approved methods. No separate payment will be made for such work.

In principle, expansion toward upper direction or horizontal direction shall be made for spans between manholes after obtaining approval from MOC / Engineer.

In installing duct / pipe at manhole position, a minimum depth below the surface and the minimum distance from duct / pipe axis to side wall / roof / base slab shall be ensured and effective duct / pipe arrangement shall be taken into consideration so that cable can be easily accommodated in manhole.

The work for feeder route where overlapped with distribution route shall be carried out with utmost care so as not to cause any damage to existing ducts / pipes of distribution route and not to interfere with cable work.

The Contractor should provide the spacers at intervals of 2 M. to hold the ducts / pipes in proper alignment. Spacers should also be provided at 1 M on either side of the joint point. Hence, for each uPVC duct / pipe, 3 spacers are provided.

Two types of spacers viz. (1) top and bottom spacers, (2) intermediate spacers are to be used for the purpose. The top and bottom spacers are single sided and the intermediate spacers are double sided.

The spacers provided at one point should be in the same vertical plane and it may be fastened tightly with vinyl rope of less than 5 mm dia over the spacers to secure the duct / pipe nest with a minimum of two bindings. Alternatively, any other method for jointing of spacers may be used with prior approval of the MOC / Engineer. In case of expansion of ducts / pipes, only the new ducts / pipes are to be connected together.

If ducts / pipes are not occupied fully in a pair of spacer, small length of 30 cm. of duct / pipe should be provided in order to have a compact strength.

Spacers supplied shall be suitable for various configurations shown in MOC Civil Drawing No. TX: 347/4/D-lA.

The Contractor may also use separate spacers with the interconnecting facilities. These spacers can be jointed for increasing the number of ducts / pipes and the minimum tensile strength of the connecting portion shall be 50 kg/sq. cm., or more. Spacers should be capable of withstanding a minimum compressive load of 500 Kg.

Spacers should be made of synthetic resin material and should be hard. Sample of spacer shall require approval from MOC / Engineer before use.

The cost of providing spacers shall be included in the cost of duct / pipe laying and no additional payment will be

made to the Contractor for providing and installing spacers.

The installation cost of laying ducts / pipes should include, asphalt, RCC / Concrete cutting, removal of tiles, pilot holes, excavation of all types of soil and rock, shuttering, dewatering, protection and transfer or rearrangement of existing cables, protection of existing MOC ducts / pipes and other services, removal of any existing ducts / pipes, laying and jointing of ducts / pipes, providing of spacers, termination of ducts / pipes in MH and HH wall, sealing of ducts / pipes in cable vaults or tunnels, sealing of all ducts / pipes in the first manhole from cable vault, sealing / plugging of all ducts / pipes in other MHs and HHs, concrete encasement, backfilling and compaction, reinstatement and retiling to match with the original surface, mandrel test, pressure test, cleaning of work site and other necessary works.

As a matter of general instructions, utmost care shall be taken at the time of installation, not to damage any cable or joints and provide perfect protection as per MOC standard and with consultation with MOC / Engineer.

The bottom of the trench shall be cleaned of all water, dirt, sand, rubbish etc., and shall be carefully leveled, watered and rammed. Where the ground is rocky, the duct / pipe shall be laid on well rammed 8 cm thick layer of earth, free from stone, arranged by the Contractor. The Contractor must examine each duct / pipe before it is laid. If any defective or broken duct / pipe is laid, the Contractor should replace it at his expense. The Contractor cannot claim any additional payment for carrying out this works.

The ducts / pipes shall not be constructed in an 'S' curve either in the latitudinal or longitudinal section except the portion near manhole in case of duct / pipe expansion as shown in MOC Drawing Nos. 347/4/D-1 & D-lA.

A maximum of two grades shall be used in ducts / pipes between manholes or handholes. Duct / pipe run shall be straight for a distance of not less than 3 M. from the face of any manhole or handhole.

Level of any part of a duct / pipe between manholes shall not be lower than the duct / pipe terminating level at the manholes to prevent stagnation of water.

Expansion of existing ducts / pipes — Where new ducts / pipes are shown on the Drawings or are directed by the MOC / Engineer to be installed to increase the size of an existing duct / pipe run, the new ducts / pipes shall be laid so as to maintain a standard duct / pipe configuration as far as is possible.

Wherever practical, and subject to the approval of the MOC / Engineer, the new ducts / pipes shall be laid on top of the existing duct / pipe. The practicality of such a procedure shall be determined by the minimum cover available and the requirements for duct / pipe termination arrangements at the adjacent manholes being acceptable to the MOC / Engineer.

Where the installation of new ducts / pipes on top of an existing duct / pipe is impractical or is not approved, the Contractor shall install the new ducts / pipes in accordance with the details shown on the MOC Drawings for "Duct Expansion" TX: 347/4/Dl & D-lA.

The method of excavation, laying of the new ducts / pipes and backfilling shall be agreed with the MOC / Engineer before work is commenced.

The existing duct / pipe run shall be adequately supported at all times to the satisfaction of the MOC / Engineer.

In all cases the new ducts / pipes shall be of uPVC.

In the case of expansion or increase of ducts / pipes the Contractor shall make necessary re-arrangement at the terminating position if proper clearances are not obtained.

Replacement of existing ducts / pipes: Where a new duct / pipe route conflicts with an existing route which is to be removed after re-cabling, the existing ducts / pipes containing cables shall be carefully broken out to provide slack in the cables to allow clear passage for the new work. Subject to the approval of the MOC / Engineer, slack may be obtained by releasing cables from clamps in adjacent manholes. The releasing of cables shall only be permitted under the supervision of the MOC / Engineer. The exposed cables shall be supported and protected to the entire satisfaction of the MOC / Engineer. Repair of ducts / pipes - The Contractor shall repair ducts / pipes in the following cases

(1) When directed by the MOC/ Engineer.
(2) Whenever existing ducts / pipes which are to be retained are damaged, the MOC's/Engineer's approval to carry out repair work has been obtained.

Ducts / pipes shall be repaired so that the original level and alignment of the ducts / pipes are maintained and so that cable can be laid or removed smoothly without obstruction.

The Contractor shall carry out all necessary excavation, backfilling and testing in accordance with the requirements of these Specifications.

The Mandrel Test shall be carried out on all repaired ducts / pipes which do not contain cables.

2101.05.1 Blocked Ducts / pipes in Manhole and Handhole Routes

If, after mandrel test, an existing duct / pipe is found to be blocked at one place in a span, it is to be repaired.

If blockages are found at more than one place in a span, the duct / pipe can be abandoned or removed, as instructed by the MOC / Engineer. New ducts / pipes to be installed in lieu of abandoned or removed ducts / pipes and it will be considered for payment purposes as the rate of laying of new ducts / pipes. Removal of abandoned ducts / pipes shall not be measured or paid separately but will be considered as incidental to the rates for installing the ducts / pipes.

2101.05.2 Jointing of Ducts / pipes

(a) Jointing of uPVC ducts / pipes using cement solvent.

The unplasticised uPVC ducts / pipes shall be jointed with an approved cement solvent resulting in permanent gas tight and watertight joints.

After cleaning the duct / pipe ends for minimum 10 cm for dirt, dust, grease, oil etc., a thin coat of solvent cement shall be applied on both sides at the joint points and pushed until snugly fit. Shear strength and long term hydrostatic pressure of cement solvent when tested shall be in accordance with BS EN 14814. Joints should not be disturbed for at least 15 minutes. At very low temperature a longer time shall be allowed.

The Contractor shall provide documentary evidence that the cement solvent proposed for use is compatible with the uPVC ducts / pipes to be used and that it has been used in similar conditions to produce watertight and gas tight joints which would satisfy the requirements of this Specifications. It shall conform to MOC Standard G20:l0:00l:32 Clause 4.9 and International Specifications (BS EN 14814, DIN 16970 or equivalent) referred therein. Before the procurement of solvent cement in larger quantities the Contractor shall supply 2 samples of joints made with the uPVC ducts / pipes and the cement solvent proposed for use along with test certificate from an independent laboratory for its strength and ability to withstand high pressure.

The Contractor shall also submit in detail, method of jointing employed to make the sample joints.

After obtaining approval from MOC/ Engineer for the sample joints, the Contractor shall submit a detailed proposal regarding method of field jointing which shall include manufacturer's recommended jointing procedure with any deviations there from. The Contractor shall demonstrate the suitability of his proposed jointing method by making 4 test joints under field conditions in the presence of the MOC/ Engineer and obtain his approval.

After obtaining approval for the test joints the Contractor shall strictly adhere to the method of jointing and any deviation from the above method shall be made only with the prior written approval of the MOC / Engineer.

The cement solvent shall be supplied in sealed containers with the manufacturer's name and date of manufacture and date of expiry of the solvent clearly marked on them. The cement solvent shall be uniform in quality and shall contain no precipitation or floating agent.

If the cement solvent is to be used with a primer the Contractor should also supply the primer along with the cement solvent. The solvent shall be stored with the containers tightly closed in a dark and cool place away from fire

(b) Cutting of ducts / pipes

Where it is necessary to cut ducts / pipes all burrs are to be removed and the cut end of the duct / pipe is to be chamfered.

(c) Protection of ducts / pipes

If the depth below the ground surface to the top of duct / pipe is less than 80 cm in the case of manhole route and less than 60 cm in the case of handhole route the ducts / pipes should be protected by concrete K-140. Ducts / pipes laid at all road crossings shall be encased in concrete K-140 irrespective of their buried depth.

A concrete encasement shall be constructed around the duct / pipe as shown in MOC Drawing No. TX: 347/4/Dl & D-lA.

Concrete:	K-140.	
Length:	As required.	
Thickness:	Ref. MOC Drawing No. TX:	347/4/Dl & D-lA.
Width:	Ref. MOC Drawing No. TX:	347/4/Dl & D-lA.

The actual method of installing the encasement shall be agreed with the MOC/ Engineer before commencement of work.

The duct / pipe arrangement and concrete protection wherever provided shall be based on the standard given in MOC Drawing Nos. TX: 347/4/D-l & D-lA.

Spacers shall be used to hold ducts / pipes in proper alignment and to keep the stipulated space between each duct / pipe. The Contractor shall submit Technical Specification, Test Report, drawings and two samples of the proposed spacers and obtain the approval of MOC / Engineer for the materials of spacers to be used before ordering any spacers for the work.

2101.05.3 Termination of Ducts / pipes

To install ducts / pipes in new or existing manhole, handhole or exchange vault, K-300 concrete shall be used to perform the waterproofing work. For manholes specified in MOC Drawing Nos. TX: 347/4/D1 & D-lA, place the water-proof concrete in 20 cms. thickness from the outside of the wall and similar terminations can be made in the case of handhole also. In the case of Exchange vault, place 100 cm. thickness water-proof concrete.

In case of R.C.C. Manholes and handholes waterproofing membrane, rubber rings and protection to waterproofing shall be provided to make the termination of ducts / pipes completely watertight. The Contractor should submit the proposal and obtain approval from MOC / Engineer before execution of work.

All ducts / pipes installed in Exchange cable vault or tunnel, and first manhole from cable vault should be sealed by spigot of synthetic rubber or compound irrespective of whether the ducts / pipes are occupied or unoccupied, in order to prevent entry of water and insect into the exchange before execution. Sealing/plugging shall be done for all new ducts / pipes in MH/HH.

In such cases, the end of ducts / pipes shall be stopped 3 cm inside the wall from the inner wall surface of manhole, handhole or exchange cable vault.

And thereafter, taking duct / pipe axis, as a centre point, finishing shall be made in a trumpet shape with mortar of 1:2 mix, so that there are no projections on the surface which may cause damage to the cable. (Refer to MOC Drawing Nos. TX: 347/4/Dl & D-lA).

In the case of uPVC ducts / pipes, the duct / pipe socket (Bellmouth) may be used at the end of duct / pipe in the manholes/handholes instead of duct / pipe termination method mentioned in the previous two paragraphs.

In case, duct / pipe bellmouths are to be used, the Contractor shall submit the sample, drawings and technical data for approval of the MOC / Engineer before commencement of the work.

The material for the duct / pipe bellmouth should be the same as that of the uPVC ducts / pipes. Regarding the size and shape of the duct / pipe socket, the Contractor may refer to the Drawings that will be supplied by the MOC so as to facilitate proper cable accommodation and to have necessary strength for the joint of the Bellmouth with the uPVC duct / pipe.

The whole work of sealing, termination of ducts / pipes into the wall, providing waterproof membrane, rubber rings, protection to water proofing, breaking of walls in existing manholes, handholes and exchange cable vault or tunnels, refacing or plastering the complete wall and dressing ducts / pipes ends shall be considered as part of the laying of ducts / pipes for the purpose of payment.

At road crossings, if the ends of ducts / pipes are not terminated in manholes or handholes, the duct / pipe openings shall be effectively sealed with an approved sealing material or end cap to prevent possible blockage of the ducts / pipes by entry of soil or water.

The duct / pipe at road crossing shall extend beyond the Kerb or asphalt line up to the centre line of the telephone reservation. Where the number of ducts / pipes to be installed is less than the maximum capacity of the manhole type designated, the ducts / pipes shall be laid to form the lowest rows of the standard configuration duct / pipe layout unless otherwise shown on the Drawings.

2101.05.4 Re-arrangement of Ducts / pipes Termination for Manhole Wall

The Contractor shall make necessary arrangement for duct / pipe terminating position whenever cable laying work inside manhole is difficult or if any instruction given by the MOC / Engineer, due to improperly existing duct / pipe terminating position in the manhole.

In such case, the Contractor shall make necessary excavation for duct / pipe -moving and re-construction of a part of manhole, if necessary.

Cost of any such rearrangement shall be included in the cost of duct / pipe laying / manhole construction.

2101.05.5 Testing of Ducts / pipes

Testing of ducts / pipes shall be carried out after laying and backfilling, but with any dewatering system still in operation, in accordance with the following requirements

All tests shall be carried out in the presence of the MOC / Engineer or their representative.

(a) Mandrel Test

All ducts / pipes in every duct / pipe run shall be checked for alignment and freedom from foreign matter by passing two brushes attached to the ends of an approved iron or hard wood or plastic mandrel through in both directions. Where necessary or where directed by the MOC / Engineer the Contractor shall clean ducts / pipes with a stiff brush.

The mandrel shall be 90 mm in diameter and not less than 300 mm in length. The ends of the mandrel shall not have more than a 10 mm radius bevel. The diameter of the brushes shall be at least 60 mm greater than the nominal diameter of the ducts / pipes and at least 80 mm in length.

All labour and materials required for the testing shall be provided by the Contractor. The testing shall be successful if the mandrel passes freely through the duct / pipe in both directions.

In the event of any length of any duct / pipe failing to pass the test the entire length of duct / pipe will be rejected.

Test results obtained by the Mandrel Test shall be properly recorded and shall be immediately made available to the MOC/ Engineer upon request. All results shall be presented to the MOC/ Engineer prior to the Final Acceptance Testing.

A Vinyl rope of 5 mm shall be provided after successful mandrel test of all ducts / pipes newly laid and after successfully rodding in existing ducts / pipes where required by the MOC / Engineer and all tested ducts / pipes shall be suitably colour marked as approved by the MOC. The Vinyl draw rope shall be left in the duct / pipe and securely

tied to the hardware at each end for future cabling.

(b) Pressure Test

After successful completion of the Mandrel Test the Contractor shall test a minimum of 10% of the uPVC duct / pipe runs in every MH/HH span (subject to minimum of one duct / pipe run) with air at a pressure equivalent to that of a head of 10 M. of water using equipment and a method of test approved by the MOC/ Engineer.

Each duct / pipe run shall be stoppered and the pressure applied for a minimum period of 10 minutes to allow stabilization of conditions within the duct / pipe. The pressuring unit shall then be shut off and the pressure must remain without measurable loss for a period of 10 minutes.

The pressure shall be measured by an approved pressure gauge accurate to 2% at the required test pressure.

In the event of any duct / pipe run failing to pass this test all duct / pipe runs in the /pipe shall be tested, and the MOC / Engineer shall decide upon the acceptability of the duct / pipe based on the results of all the tests. Should the MOC/ Engineer decide that the duct / pipe is unacceptable the Contractor shall carry out such remedial, repair or replacement works as approved by the MOC/ Engineer and the duct / pipe shall be retested.

2101.05.6 Retesting

Should the MOC/ Engineer have cause to believe that damage or disturbance has occurred to any duct / pipe at any time after completion of the pressure test, he shall have the right to order retesting of the duct / pipe by the mandrel and/or pressure test.

2101.05.7 Acceptance of Ducts / pipes for Payment Purposes

Notwithstanding any approvals given by the MOC / Engineer in accordance with the requirements stated above for testing, the installed ducts / pipes shall not be considered as accepted for payment until they have passed all the tests specified above and written approval has been obtained from the MOC.

2101.05.8 Leakage of Ground Water

Any leakage of ground water into any duct / pipe run of any duct / pipe shall be cause for the MOC/ Engineer to reject the whole of that duct / pipe between adjacent manholes or handholes.

2101.05.9 Installation of subducts / pipes

The Contractor has to install 4(four) numbers 32 mm dia HDPE subducts / pipes of different colors (GREEN, YELLOW, ORANGE, BLACK) having pulling wire (rope) in then to lay / relocate new /existing optical fibre cables .Two numbers of 100mm dia ducts / pipes to be subducted along all new or relocated routes irrespective of number of duct / pipe way.

The Contractor has to obtain material approval from MOC / Engineer. All subducts / pipes must be installed in top layer of duct / pipe configuration in consultation with MOC / Engineer. The material of HDPE sub ducts / pipes must be as per MOC's Specification no. G20: 10: 001:40.

2101.05.10 HDPE Subducting Accessories.

The Contractor shall supply suitable rubber plugs for plugging the 100 mm ID PVC sub-ducted ducts / pipes with 4(four) numbers 32 mm dia HDPE subducts / pipes. The plugs shall withstand the climatic condition and soil/water contents. The plugs for subducts / pipes shall be supplied by the Contractor. The plugs for the subduct / pipe shall be suitable for tying the puling rope specified in Clause 2101.05.9 of these Specifications.

2101.06 BACKFILLING

No backfilling shall be commenced before obtaining the approval of the MOC / Engineer for the works covered by the backfilling.

The space outside the walls of manholes, handholes, and around ducts / pipes shall be carefully filled in with earth free from stones and rammed, care being taken to avoid any damage.

Backfilling and compaction around ducts / pipes shall be carried out as each layer of duct / pipe is installed using fine sand (Filler material). If more than one layer of ducts / pipes is to be installed the spacers required for supporting the second layer of ducts / pipes must be pushed on before the filler material is bedded around the first duct / pipe layer. When laying all further layers proceed in a similar manner.

The filler material introduced into the trench should be watered and compacted between the ducts / pipes with wooden rammers. The filler material is levelled with each laid out uPVC duct / pipe layer in succession, whereby the thickness of filler material above the upper most duct / pipe layer must be 10 cm.

The upper layer above ducts / pipes shall be filled only after approval of pressure test and compaction between ducts / pipes by MOC's representative / Engineer's representative.

All excavated materials shall be screened to obtain soil free from rubbish, stone, deleterious materials etc. and the soil shall be approved before backfilling. This soil shall be replaced in layers not exceeding 20 cm thick after compaction, the compaction field density to a degree of 95% in paved areas and 90% in unpaved areas of the maximum possible dry density of the same type of soil as tested after being compacted in the laboratory or to the requirements of Section 2 (Earthworks) of these Specifications. Compaction in the laboratory will be achieved by modified proctor method. Power rammers shall be used whenever practicable and where such use is impracticable, hand ramming may be employed.

Degree of compaction of backfilled material shall be tested in accordance of ASTM or BS or Kuwait Standard Test Procedure. Test should be carried out at the rate of at least one specimen per span per layer or as directed by the MOC / Engineer. In case the specimen does not confirm to the required density and thickness, additional test may be taken to ascertain the limit of failing duct / pipe span, after which the Contractor shall re-excavate, breakup, fill, water, compact and level the layer again, if necessary, replace the material or add new earth at his own expense. The Contractor shall allow in his daily schedule of work enough time to permit the performance and checking of test before proceeding to any subsequent operation. Any faulty compaction shall be rectified by the Contractor to the satisfaction of the MOC / Engineer or their representatives. The test for Compaction shall be performed by the Contractor at Government laboratory at his own expense.

Test result obtained through proctor test method shall be properly recorded and be included as document for Final Inspection and Acceptance Tests.

The Contractor shall remove all surplus material such as waste earth, broken ducts / pipes, and all debris from site and leave all affected areas and surfaces in a clean and proper condition to the satisfaction of the Engineer and Municipality Inspector. The Contractor shall furnish a certificate that all surplus materials have been cleared after the completion of the work; this certificate shall accompany the Contractor's Application for payment.

The Contractor shall daily maintain the level of all road crossings by providing fill as necessary until re-surfacing

The surface of all footway trenches shall also be regularly maintained by the Contractor until such time as he shall undertake permanent reinstatement.

Poor compaction of fill, failure to leave the site of work clean and tidy or non-observance of any requirements laid down above or of directions given from time to time will be regarded as a serious breach of Contract which if repeated, be sufficient to justify the Employer taking action against the Contractor.

The Contractor shall reinstate trenches in existing paved or unpaved footways to match the original surface. Reinstatements of concrete in situ or concrete flags and tile / block pavings shall be carefully executed and matched to the original surface. Any new flags or tiles / block used in replacement of broken / chipped ones shall match the original in colour, size, design and shall be mortar bedded and jointed except for blocks which are to bedded on sand and butt jointed. All necessary materials, labour and equipment shall be provided by the Contractor at no additional cost.

2101.07 MANHOLES AND HANDHOLES

2101.07.1 Drawing References

The Contractor shall construct manholes, handholes, etc. according to the following latest standard amended Construction Drawings of the Ministry of Communications:

No.	Description	MOC Drawing No.	No. of Ducts / pipes	No. of Sheets
1	Handhole (Precast or insitu)	TX:371/5A	Upto 2	1
2	S1 Type Manhole (reinforced)	TX:347/9-1R	4	1
3	S2 Type Manhole (reinforced)	TX:347/9A-1R	5 – 9	1
4	S3 Type Manhole (reinforced)	TX:347/9B-1R	10 – 20	1
5	S4 Type Manhole (reinforced)	TX:347/9C-1R	21 – 28	1
6	S5 Type Manhole (reinforced)	TX:347/9D-1R	29 – 40	2
7	S6 Type Manhole (reinforced)	TX:347/9E-1R	41 – 48	2
8	L1 Type Manhole (reinforced)	TX:347/9-2R	4	2
9	L2 Type Manhole (reinforced)	TX:347/9A-2R	5 – 9	2
10	L3 Type Manhole (reinforced)	TX:347/9B-2R	10 – 20	2
11	L4 Type Manhole (reinforced)	TX:347/9C-2R	21 – 28	2
12	L5 Type Manhole (reinforced)	TX:347/9D-2R	29 – 40	3
13	L6 Type Manhole (reinforced)	TX:347/9E-2R	41 – 48	3
14	T1 Type Manhole (reinforced)	TX:347/9-3R	4	2
15	T2 Type Manhole (reinforced)	TX:347/9A-3R	5 – 9	2
16	T3 Type Manhole (reinforced)	TX:347/9B-3R	10 – 20	2
17	T4 Type Manhole (reinforced)	TX:347/9C-3R	21 – 28	2
18	T5 Type Manhole (reinforced)	TX:347/9D-3R	29 – 40	2
19	MT2 Type Manhole (reinforced)	TX:347/9A-4R	9	2
20	MT3 Type Manhole (reinforced)	TX:347/9B-4R	10 – 20	2
21	MT4 Type Manhole (reinforced)	TX:347/9C-4R	21 – 28	2
22	MT5 Type Manhole (reinforced)	TX:347/9D-4R	29 – 40	2
23	Exchange Manhole (reinforced)	TX:347/5R		2
24	Pre- Cast Manhole	TX:347/15 & 15-1		2
25	Standard Duct / pipe Arrangement, Encasement for existing and proposed ducts / pipes, termination of ducts / pipes.	TX:347/4D-1 & D-1A		1
26	Base of Cabinets.	TX:347/6B/D		1
27	Iron work and construction of Necks for Manhole.	TX:348/1		1
28	Laying & Coupling of lead-in duct / pipe	TX:347/4D		1
29	Standard Draw Box and Sumphole Cover for Manhole.	TX:483		1
30	Typical Services Distribution in sidewalks.	TX:320/G		1
31	Manhole Cover and Frame	TX:481		1
32	Handhole Cover and Frame	TX:482		1
33	Guard Post for Cabinet	TX:449/1		1
34	Symbol for Telephone Network	TX:347/8D		1

NOTES 1. All manholes shall be constructed with neck as shown in MOC Drawing TX:368/l.
2. Manhole Covers recess to be filled with K-300 concrete.

2101.07.2 Construction

K-300 concrete shall be used for construction of manholes and handholes. A leveling course with 10 cm thick K—140 concrete shall be provided below the bottom slab of all R.C.C. manholes/handholes. The offset for the leveling course shall be of 10 cm on all sides.

The Contractor should inform the MOC / Engineer to check the measurement of reinforced bars according to the diagrams prior to the placing of concrete in the mould in case of R.C.C. manholes/handholes.

R.C.C. manholes situated wholly or partially below the ground water level shall be protected by applying self adhering waterproofing membrane to the external surface. Manholes situated wholly above the ground water level shall be protected by painting two coats with rubberised bitumen. The Contractor shall submit to the MOC/ Engineer for approval the samples and procedure of work before execution.

Pre-cast manholes shall be provided with 100 mm uPVC bell mouths on all faces according to the full capacity of the manhole.

Pre-cast handholes shall be terminated with 2 Nos. 100 mm uPVC bell mouths on each terminated face and two Nos. 50 mm uPVC bell mouths on two terminating face for lead-in duct / pipe termination. Cast insitu handholes shall be terminated with 100 mm uPVC ducts / pipes instead of bell mouths. Two Nos. 50 mm uPVC lead-in duct / pipe termination of 1 M. length shall be provided on each side of cast insitu handholes instead of bell mouths. Duct / pipe ends, bell mouths and lead-in ducts / pipes which are not extended shall be sealed in an approved manner at both ends.

In all R.C.C. manholes / handholes (cast insitu) in which number of ducts / pipes terminated is less than the full capacity, additional number of ducts / pipes required to make up full capacity shall be installed for a length of 1 M. on each termination face and their ends shall be sealed in an approved manner.

Wherever there is existing cables, MOC proposes insitu manhole & hand hole to be constructed.

All the above work including materials shall be considered as part of the work of manhole / handhole construction for purpose of payment.

Bell mouths for manhole / handhole shall be approved by the MOC/ Engineer before execution.

Iron works for manhole and handholes shall conform to the materials and suppliers specifications. Anchor iron should not be placed by breaking a part of manhole but should be placed before placing of concrete. For RCC manholes, anchor iron should be set in shuttering and concrete cast.

Position of step installation shall be between necks and slab in case the neck is provided and at a middle point of slab in case neck is not provided.

The cement blocks approved by the MOC / Engineer for repair of existing manhole/handhole etc. shall be properly bedded in mortar with all joints full, courses level and faces vertical. Cement blocks shall be pre-soaked for a minimum of 4 hours immediately prior to use.

Exposed faces and internal faces of manholes or handholes shall be finished smoothly as there is no ruggedness of cement and bond and plaster as shown in the Drawings.

The block work for the outer face of MH/HH should be well pointed.

In paved areas (Carriageway, Footways etc.) MH & HH covers shall be set to the same level and to the same falls as the surrounding paved areas. In unpaved areas MH neck shall be set 200 mm above finished surface level unless otherwise shown on the Drawings or directed by the MOC / Engineer. In all cases the Contractor should collect information about future plan of road and should decide the level in consultation with the MOC/ Engineer.

The Contractor may also be required to build manholes and handholes of dimensions different from the standard type of manholes and handholes. In this case, the Contractor shall prepare new drawings and submit them to the MOC / Engineer for due approval and shall submit the strength calculations of the structure also. The above mentioned work such as designing, drawing and strength calculation etc. of special type of manholes and handholes are duly a part of the work of the Contractor and hence the Contractor cannot claim any additional payment for this work.

If the variation in the total quantity of reinforcement concrete + cement concrete + cement blocks due to the modification, alteration etc. is less than 15% of the total quantity of the above items of each standard manhole,

handhole, no extra charges are payable. For calculation of the excess mentioned above, the neck shall not be taken into consideration.

The rate for the special type of manholes and handholes shall be calculated on pro-rata basis of the manhole / handhole volume as against that of similar types of standard manholes / handholes.

Duct / pipe termination in manholes and handholes shall be in position so as to facilitate accommodation of cables. When new ducts / pipes are installed or expanded in the manhole they shall be terminated at the centre portion of the manhole in the horizontal plane as far as possible. Minimum distance between the top duct / pipe axis and the roof slab or the bottom duct / pipe axis and the base slab shall be 40 cm. Corresponding ducts / pipes shall be terminated on the same level as far as possible. However in L & T type and Exchange Manholes, level difference between ducts / pipes fixed in the straight direction and branching off direction should be not less than 34 cm to avoid interference in cable laying and jointing. The angle of ducts / pipes termination with manhole and handhole shall be at right angle. If this is not possible the Contractor should submit the longitudinal profile drawings of the proposed duct / pipe route showing the location, size and elevation etc. of all other services including MOC ducts / pipes, handhole and manhole to the MOC / Engineer for approval. If the number of ducts / pipes terminated is less than the maximum capacity of the manhole / handhole spare ducts / pipes of length 1.0 m shall be provided to obtain the maximum capacity of the manhole / handhole. The ends of these ducts / pipes shall be sealed in accordance with these Specifications. No additional payment will be made for these spare ducts / pipes.

Cable racks fitting position for S-1 and L-1 type manholes shall be only one side (Building side) and so position of duct / pipe termination shall be at the cable racks fitting side from the centre line of the manhole.

In the case of manholes in water-logged areas, water-proofing, shall be done by the Contractor at his own expense.

The manholes and handholes shall be thoroughly cleaned after construction is over and shall be free from water, dirt, sand, rubbish etc.

All manholes and handholes shall be watertight and constructed at locations as shown in the approved drawings.

The Contractor shall provide housing base on the roof of new manhole designated for, installation of distribution cabinet in accordance with MOC Drawing No. TX 347/6B/D or as approved by MOC / Engineer according to the type of cabinet used.

In case of fixing of cabinet, on an existing manhole, the Contractor shall construct cabinet base on the new slab after demolishing the roof in full and in accordance with detailed drawings, approved by the MOC / Engineer.

Removal of cabinet from existing manhole shall be made by removing bolts fixed to the housing base and then the base may be removed. The gap shall be filled with K-300 concrete after chiselling a portion about 20 cm in width and 5 cm in depth. Cabinets shall be returned to the MOC Store.

The Contractor shall provide necks for all newly installed manholes (Refer to MOC Drawing No. TX 368/1). The construction of neck shall be of R.C.C.

Height of the neck shall generally be 20 cm. Necks of height above 20 cm up to 60 cm is allowed if the site conditions necessitate height of necks to be over 20 cm. Whenever the height is less than 20 cm or more than 60 cm, the Contractor shall submit the necessary document for the approval of MOC / Engineer. A neck higher than 60 cm may be directed by MOC / Engineer in special cases.

Contractor shall fix the number plates for each new and existing manholes and handholes respectively.

The number plate shall be of size 100 mm x 60 mm and shall be made of stainless steel plate 1 mm thick. The plate shall be provided with four (4) holes 4 mm diameter for fixing on wall with screws and dowels. Letters shall be of size 7 mm, embossed or engraved and painted in black with white background painting in the plate.

Number plate for manhole shall clearly mention name of Exchange area, manhole number, type and size of manhole and year of installation. Number plate for handhole shall mention name of exchange area, handhole number and year of installation. Sample of number plate and method and position of fixing should be approved by MOC, before commencement of work.

Number plate shall be fixed with screws and dowels on the neck of manhole or the shorter side wall of handhole at 10 cm below the frame.

In the case of existing manhole without neck, number plate shall be fixed at roof slab near the frame of manhole cover.

The Contractor may have to construct neck on existing manholes to a height up to 20 cm or above 20 cm up to 60 cm depending on the ground level conditions. A neck higher than 60 cm may be directed by MOC / Engineer in special cases.

The existing manhole cover and frame shall have to be recovered in the first stage, taking due care for the existing cables, joints, fixtures etc., inside the manhole. The existing roof shall be chiseled to a depth of 5 cm and width of 25 cm around.

Construction of the neck is the same as in the case of new manhole construction (Refer MOC Drawing No. TX: 368/1).

The surface of roof around the neck shall be given a smooth finish and the manhole cover placed after curing.

In case that neck of existing manhole is just out of the road surface, banking around the neck should be done to avoid danger to pedestrians and vehicles etc. The correct banking material should be piled up to the same level as the neck with easy slope and should be compacted sufficiently so that it is not blown away by wind etc.

Contractor should investigate about the places where the banking is to be done at the time of field survey and should obtain approval from MOC / Engineer.

In case the existing manhole or handhole is to be demolished and re-constructed or a manhole or handhole is to be newly established in the middle of the existing duct / pipe route, the cable in the duct / pipe concerned and other facilities shall be supported and protected with a completely safe method as approved by the MOC / Engineer.

Manholes or handholes and the portions of the duct / pipe termination shall be such that on completion, all existing cables will be fully supported on the cable racks.

Existing ducts / pipes falling within the newly constructed manhole shall be cut without damaging cables, if required by MOC / Engineer. Such cutting and removal of ducts / pipes shall be treated as part of manhole construction.

The Contractor shall install a manhole cover to the existing manhole where cover is missing or damaged. Manhole cover's voids shall be filled with K-300 concrete.

The existing manhole roofs which have slid or are damaged, shall be replaced. In demolishing the roof for replacement, care must be taken not to cause any damage to cables and other facilities in the manhole.

In case of having duct / pipe projected inside the existing manhole, the Contractor shall shave the inner wall face of the manhole in the area of 3 cm of duct / pipe circumference and 3 cm in depth to cut the duct / pipe off.

The treatment as mentioned in Clause 2101.05.3 shall be applied. Duct / pipe face shall be finished by plastering. In this case, care shall be taken not to cause damage to the existing cable.

In case of removing the existing manhole and handhole, the Contractor shall perform the removal work with utmost care, so that the jointing points and other places are not damaged. In case new manhole construction is required at the same place, where the existing manhole has been removed, costs for excavation, backfilling and restoration shall not be duplicated in the price schedule.

In case, cable racks are not sufficient in quantity or corroded in the existing manhole, the Contractor shall provide cable racks at the specified position, in accordance with the specified Drawing and the specified position for supporting cables. For installing the cable rack, it is necessary to make a cavity at the position of fixing the hook-bolt and to fill the same with mortar (mixing ratio -Cement, Sand 1:2) and insert the hook-bolt in to the cavity. Surface shall be finished with plastering.

The Contractor shall provide iron ladder for the existing manhole, if the ladder is not provided with the manhole. The number duly embossed or engraved on it.

Necessary step shall be installed. Position of step installation shall be between neck and slab in case the neck is provided and at a middle point of slab in case the neck is not provided. If the neck height is more than 40 cm, steps shall be provided at every 25 cm.

Pre-cast handhole may be constructed for the new handhole route where there are no existing cables (Refer to MOC Drawing No. TX: 371-5A). Approval to be taken from MOC /Engineer before execution.

Pre-cast manholes can also be proposed by the Contractor where there is no existing cables and approval obtained from the MOC / Engineer before execution. Design details and calculations must be submitted by the Contractor. Rates shall not exceed rate for similar RCC manholes and shall be subject to approval of the MOC / Engineer.

The newly constructed manholes shall be equipped with the following

a) Manhole Cover and Ring according to MOC Drawing No. TX: 481.
b) Steel Ladder. Cable Racks.*
c) Cable Supports.
d) Steps.
e) Anchor Iron and Sump hole Cover.
f) Number Plate.

*Each Cable Rack shall be equipped with Cable Supports in all positions (Full capacity).

The newly constructed handhole shall be equipped with hinged type handhole cover and its frame (MOC Drawing No. TX - 482 A), cable rack for handhole and number plate.

2101.08 LEAD-IN DUCT / PIPE

The Contractor shall lay lead-in duct / pipe (for laying the lead-in cable to the subscriber's premises or building from manhole, handhole or pole) to the subscriber's intake duct / pipe or draw box fixed on the boundary wall and shall join the lead-in duct / pipe with the intake duct / pipe or draw box.

The lead-in ducts / pipes shall be of uPVC from the manhole, handhole or pole to the draw box, except the exposed portions. The exposed portions near the draw box or pole shall be of galvanized iron in accordance with material specifications. Suitable adaptors according to the size of the ducts / pipes must be provided by the Contractor to connect the G.I. and uPVC ducts / pipes with the approval of the MOC / Engineer.

If there is no draw box on a boundary wall in the subscriber's premises, as most of the subscribers have intake duct / pipe ready up to the outside of their premises, the Contractor shall carry out the field survey at the site, locating the existing duct / pipe by excavation, if necessary, and shall arrange to have the new uPVC ducts / pipes effectively coupled to the existing duct / pipe, adopting a coupling and have the proposed method of coupling approved, by the MOC / Engineer. A draw rope of vinyl material of minimum 5 mm dia shall be provided throughout the full length of pipe from handhole to Draw Box, in order to lay cable at a later stage, securely tied to its hardware at each end.

In case, no intake duct / pipe exists in the subscriber's premises, the Contractor shall obtain the subscriber's consent on the position of Draw Box to be fixed on a boundary wall, and with the approval of the MOC / Engineer, the Contractor shall lay lead-in duct / pipe from manhole, handhole or pole to the boundary wall of the subscriber and shall fix Draw Box to the end of the lead-in duct / pipe raised to 160 cm from the ground level wherever possible, along the boundary wall. Alternatively, if so required by the MOC / Engineer, the Contractor shall inform the subscriber, in writing, to install the intake duct / pipe. In case there is no boundary wall, lead in duct / pipe shall be terminated in a draw box 300 x 300 x 75 mm at a place approved by the MOC / Engineer.

In case of rehabilitation of area along with other services, the Contractor has to install a new lead-in pipe along with draw box to each house.

The route of the lead-in pipe shall be the shortest possible. In footpaths, care is to be taken of other services and standard reservations as shown in MOC Drawing No. TX: 320/G.

The lead-in pipe shall bend smoothly at radius more than 6 times the outer diameter. The depth from ground surface to the top of the duct / pipe should be 40 cm. The pipe shall be so coupled throughout the whole length that there will be no difficulty in laying of the lead-in cable.

Joints of lead-in uPVC ducts / pipes shall be made with uPVC couplings and sealed with solvent cement (BS EN 14814).

Coupling for jointing uPVC duct / pipe to 50 mm G.I. pipe should be made of uPVC and have one end threaded and the other end shall be suitable for sealing with solvent cement.

In case of existing subscriber duct / pipe having different diameter, a reducing coupling shall be used.

The Contractor shall in these cases, submit sample for approval of MOC / Engineer.

Premade bends should have a minimum radius of 6 times the outer diameter of the duct / pipe (See MOC Standard G20:10:001:32)

All galvanised steel ducts / pipes to be buried, should be given a protective coating of bitumen.

The Contractor shall write the D.P. Number on the D.P. Box cover, installed on the pole or boundary wall as well as draw box, as instructed by the Ministry of Communications.

Any damage to subscriber's property during the work shall be made good by the Contractor at his own expense.

After laying the ducts / pipes, both ends shall be carefully sealed with removable sealing compound to prevent insects, vermin and reptiles getting entry into the building.

The Contractor shall reinstate all trenches for laying lead-in duct / pipe in paved or unpaved footpath and all other places to match the original surface.

In case that lead-in duct / pipe is newly laid or replaced in manhole or handhole, regardless of existing conditions, in general principle, the duct / pipe should be fitted on the same side as main duct. However, in case it is not possible to fix the duct / pipe on the same side, the Contractor should take approval from the MOC / Engineer to fit the ducts / pipes at a different side than that of the main duct.

The cost of a lead in pipe shall include all accessories, Draw Box / DP Box, Duct / pipe Termination in Box and handhole Coupling to existing subscriber's ducts / pipes, numbering etc.

2101.09 CLEARANCE TO UNDERGROUND SERVICES AND FACILITIES

Storm water and Sanitary Sewers, Water and Gas Mains and other Services Duct / Pipe lines - Subject to the requirements of other service Ministries, Authorities and Companies, a minimum clearance of 150 mm shall be provided between telephone installations (ducts / pipe and cables) and storm water and sanitary sewers, water and gas mains and other services duct / pipe lines.

Electricity Supply Poles and Pylons, Road Lighting Poles and Masts, Traffic Sign and Signal Poles, Gantries and Overhead Supports - A minimum of 150 mm shall be provided from the above facilities and their foundations to any telephone installations.

Electric Cables — The minimum clearance between telephone cables and electrical cables shall be as follows:

(i)	High Voltage Single Core Cables of Voltage greater than or equal to 650 V, but not more than 132 KV	450 mm.
(ii)	High Voltage Multicore 'Cables of Voltage greater than or equal to 650 V, but not more than l32 KV.(with resistance earthing of neutral for 132 KV).	300 mm.
(iii)	Low Voltage cables of Voltage less than 650 V.	150 mm.

Exceptionally, with the permission of the MEW and the MOC, the clearances given in (i) and (ii) above may be reduced at crossings of electric cables to a minimum of 150 mm. In such cases, a 75 mm. thick layer of K-140 concrete shall be placed between the electric cables and the telephone cables. The concrete layer shall be sufficiently wide to overlap the electricity cables by 75 mm on either side and be not shorter than the width of the telephone plant.
The minimum clearance between telephone installations and electric cables of voltage of 132 KV with direct earthing of neutral and all cables carrying voltages greater than 132 KV shall be determined as a special case for each location.

No reduction of the clearance shown on the Drawings will be permitted without prior approval of the MEWand the MOC.

The Contractor shall be responsible for obtaining details of the type of electric cables to be crossed by or to run adjacent to the telephone plant to be installed under the Contract.

2101.10 INSTALLATION OF DISTRIBUTION CABINETS

In case distribution cabinets are required to be supplied and installed by the Contractor, the following specifications shall be applicable.

Distribution cabinets of size 2400 pairs shall be supplied and installed by the Contractor. The locations of these cabinets will be shown in the Drawings. The cabinet shall be of such a size that it can be installed on any type of manholes.

It shall be installed on a reinforced concrete base in accordance with MOC Drawing 347/6B/D, or as approved by MOC / Engineer according to the type of cabinet used, to be cast along with the roof of the manhole (while the manholes being newly constructed) or the base may have to be cast over an existing manhole.

The foundation bolts suitable for the make of the cabinets shall be fixed while casting the concrete.

Special care shall be taken to ensure that the articles shall be securely fixed / embedded with correct position and the Contractor shall, at his own expense, provide all necessary templates, temporary supports and other plant and labor required.

Items to be embedded in the concrete shall be clean and free from oil or foreign matter that would weaken the bond of concrete to these items.

The Contractor shall make the distribution cabinet watertight, by sealing all apertures in the cabinet base.

The distribution cabinet shall normally be installed at the down side corner of the manhole, on the building line side, so that it is parallel to the road and facing the building side. In case of cabinets with doors on both sides, the side facing building will be front side (Face A) and side facing road will be back side (Face B). The position and type of the cabinet shall be approved by MOC before execution.

The Contractor shall write the cabinet number at front and back on each cabinet as instructed by the MOC. The lettering shall be 100 mm block lettering.

The Contractor shall install guard posts around manhole cabinets newly installed and existing cabinets as shown in MOC Drawing No. TX: 449/1 to protect the cabinet from vehicles etc.

The Contractor should investigate about cabinets for which guard posts are to be installed at the time of field survey, and should obtain approval from MOC.

The cabinets shall be earthed as specified in MOC Standard G20:10:001:24. The earth wire entry duct / pipe installed in the cabinet base shall be sealed properly after installation of earth wire, to prevent entry of water. The Contractor should include in his field survey report the details of existing cabinets which are to be earthed.

2101.11 CONTRACTOR'S RESPONSIBILITY FOR PROTECTION OF THE INSTALLED PLANT

The Contractor shall be solely responsible for maintenance and protection of plant installed by him until such plants are provisionally handed over to MOC. In case any damage is caused to MOC Plant before provisional handing over, due to work by other contractor / Agencies, it is the responsibility of the Contractor himself to have the plant repaired without delay and any cost incurred due to such damages should be settled with such Agencies / contractors and any of the above responsibilities shall not be transferable to MOC / Employer in any manner.

2101.12 COMPLETION REPORTS AND DRAWINGS

On completion of work, the Contractor shall prepare a written report of the final acceptance testing including the tabulated results of all mandrel, pressure and compaction tests carried out for the MOC / Engineer which shall be accompanied by

(a) Set of completion drawings 6 copies with newly installed plant marked in red and As-built drawings to scale 1:2000 and conforming to A-l size showing actual status of As-built facilities. As-built drawings shall include six sets of prints and one set of Auto CAD polyester film of 75 Microns (0.003"), from which prints can be taken out, also 2 sets of soft copies (CD's).

(b) All As-built drawings must be Geographic Information Compatible pro-forma with Coordinates as per WGS 84 GPS Projection & datum system in Decimal / Degree.

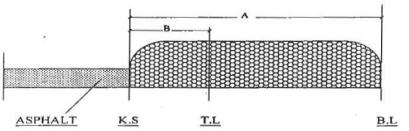
(c) Key map to a suitable scale showing clearly the location of Area / Street / Road.

(d) The As built drawing should include the following information

(i) Name or number of main road, street name / number.
(ii) Width of road / footpath.
(iii) Distance of central line of plant from Kerbstone or centre of road.

MOC's centre line from kerb stone	Foot Path Width	Width of road	Road Name Road No.

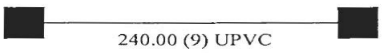
CROSS SECTION OF ROAD



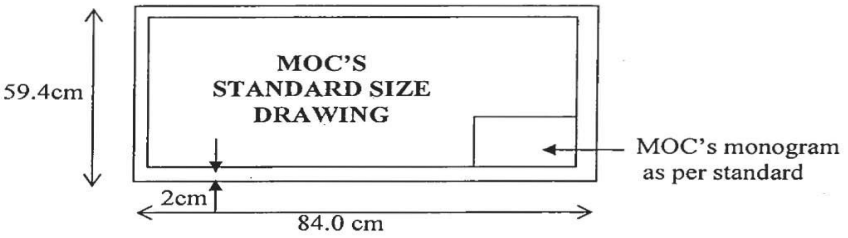
Where,

A - Width of Footpath.
B - MOC centre line from Kerb Stone.
T.L - Telephone Line.
K.S - kerb Stone.
B.L - Building Line.

(iv) Manhole No., Handhole No and drawing numbers.
(v) Type of MH S1, S2 etc. and if ordinary or R.C.C.
(vi) MH Span, HH Span (from Centre to Centre of HH or MH).



(vii) Cabinet No., Draw Box No., DP No.
(viii) Nos. and types of ducts / pipes.
(ix) Depth of top level of ducts / pipes if it exceeds 1 M. (complete profile drawings to be submitted).
(x) Details of protection of ducts / pipes (concrete surroundings/encasement to be marked).
(xi) Size of drawing.



(xii) Direction of north may be marked on location plan & detail plan.
(xiii) When depth of top level of ducts / pipes if it exceeds 1M, complete profile drawings should be submitted.
(xiv) Details of protection of ducts / pipes (Concrete Encasement) to be marked.
(xv) As built quantities:

Legend	**Quantities**
Existing Hand hole.	
Existing Manhole Type S-1	
Existing Manhole Type L-1	

When the MOC/ Engineer is satisfied that the work is complete, that all testing as specified have been carried out, and all documents have been submitted, he will inform the Ministry of Communications, who will carry out a final acceptance inspection for the provisional acceptance of the plant.

(e) In case of partial inspection also the above drawings and details must be submitted by the Contractor to MOC / Engineer.

2101.13 INSPECTION AND ACCEPTANCE TESTS

The Inspection and Acceptance Tests specified herein shall be made after the physical completion of the external plant facilities and shall not replace the normal supervision, inspections and tests to be made by the Contractor and the MOC / Engineer during the progress of the construction work. All Inspection and Acceptance Tests specified herein shall be performed by the Contractor at his cost under the supervision of MOC / Engineer. Any reinstatement after the inspection is to be done by the Contractor at his cost.

The main items of Inspection and Acceptance Tests by Ministry of Communications are given below:

Inspection
(1) Structure.
(2) Sump Hole.
(3) Accessory Material.
(4) Pulling Bolt (Anchors)
(5) Step.

Acceptance Tests
(1) Mandrel Test.
(2) Pressure Test for uPVC Ducts / pipes.
(3) Proctor Compaction Test.

(6) Ladder.
(7) Cover Greasing.
(8) Cleaning
(9) Duct / pipe Laying and Termination.
(10) Manhole No. Plate.
(11) Cabinet.
(12) Draw Box.
(13) Lead – in Duct / pipe
(14) Handhole No. Plate.
(15) Water tightness of MHs/HHs.
(16) Break Inspection (To Ascertain the depth of duct / pipe, concrete encasement, pointing, providing of spacers) and any other required information.

"The physical completion of External Plant facilities" means

(A) Manholes and Ducts / pipes for Feeder Cables.

After all works concerning Manholes and Ducts / pipes for the Feeder Cables to the farthest point from the Exchange in each Subscriber direction are completed.

(B) Handholes and Ducts / pipes for the Distribution Cables.

After all works concerning handholes and ducts / pipes from a Cabinet to its dead-end for the Distribution Cables are completed, including lead-in duct / pipe.

Necessary equipment, laborers and costs for the Acceptance Tests and for any other tests required under this Specification shall be provided by the Contractor. Written reports including the tabulated results of the tests made by the Contractor shall be prepared, signed by the Contractor and the MOC / Engineer and submitted to MOC upon completion of the work.

The Contractor shall perform Mandrel Test by using hard wooden mandrel of 90 mm in diameter and 300 mm in length. The Contractor shall also perform Pressure Test as per Clause 2101.05.5(b) of this Specification. Ducts / pipes to be tested shall be designated by the Ministry of Communications.

In case the test mandrel cannot be pulled through the duct / pipe or failure of pressure test during the acceptance tests the ducts / pipes shall be rejected.

The Contractor should repair all defects in the plant and re-offer for second inspection within 21 days from the date of first inspection. If the work is again rejected in the second inspection or if the Contractor fails to repair the defects within 21 days, MOC reserves the right to accept the work with due compensation from the Contractor to the MOC (through the Employer) for repairing the defects. If third inspection is required, MOC (through the Employer) may charge the Contractor an inspection fee which will be decided by MOC. These compensation and other charges which will be done through the Employer, are without prejudice to any provision contained in the Contract or penalty for delay etc.

2101.14 MEASUREMENT AND PAYMENT

2101.14.1 Method of Measurement and Basis of Payment

Steel Reinforcement

No separate payment shall be made for steel reinforcement, its fabrication, placement in RCC works, which will be deemed to be included in the RCC MH/HH or relevant item in the Bills of Quantities.

Formwork for Concrete

No separate payment shall be made for erecting and removing form work, curing etc.

Supplying & Laying of unplasticised PVC Ducts / pipes

Ducts / pipes are measured in meters, and the rates of related works are deemed to include supply of ducts / pipes, fittings, bends, cleanser, jointing adhesive and spacers, protection, laying, and jointing and testing.

The work shall include excavation, backfilling, encasing with concrete when required, carting away surplus excavations and cleaning of site, and items/work described elsewhere in these Specifications that their costs are included in the supply and laying of ducts / pipes. All work to be as per Drawings and Specifications and to the satisfaction of the MOC / Engineer.

Pipes/ducts encased in concrete shall be measured separately than that directly burried

Supplying & Laying of Lead-in ducts / pipes and supplying & fixing of G.I. Boxes

Lead-in ducts / pipes are measured in meters, and the rates of related works are deemed to include: Supply of uPVC Ducts / pipes, Bends, Galvanized Iron Ducts / pipes, Bends, draw boxes and accessories, protection, laying buried or fixing on walls or poles and jointing, applying one coat of approved bitumen compound.

The work shall include excavation, backfilling, replacing existing ducts / pipes, removal & carting away abandoned ducts / pipes and excavation, cleaning of site, and items/work described elsewhere in these Specifications that their costs are included in the supply and laying of lead-in ducts / pipes. All work to be as per drawings and specifications and to the satisfaction of the MOC / Engineer.

Construction of Manholes and Handholes

Manhole/handhole shall be measured as a complete unit, furnished, installed, put into operation after testing and accepted as meeting the Specifications in all respects.

Construction of manholes and handholes as per Contract Drawings including excavation, backfilling, carting away surplus excavation, concrete building, RCC base, walls, top slab, and neck for M/H and concrete surrounding for H/H, supply and fix complete ironwork and cast iron cover, frame, ladders and number plate and, items/work described elsewhere in these Specifications that their costs are included in the cost of constructing M/H and H/H. All work to be as per Drawings and Specifications and to the satisfaction of the MOC/ Engineer.

Rates for all the above items of works shall include cost of field survey, all associated works, safety precautions and protection of all existing services, corrections/alterations/demolitions and adding/changing cable racks, ladders, steps of existing manholes and handholes, bases for cabinets, submission of shop drawings, as built drawings and documentations, and all types of testing.

In carrying out the work, if it proves necessary to move a cable or other existing MOC installation, the Contractor may do so with the approval of MOC/ Engineer at his own expense provided that it does not interrupt the normal telephone service and the moved cables/installations are returned to their original place or suitable place designated by MOC/ Engineer after the completion of the work. In case the depth of the existing ducts / pipes is reduced due to subsequent change in levels, the ducts / pipes should be encased with concrete.

The amount of completed and accepted work measured as provided for above, shall be paid for at the unit prices for the Pay Items inserted in the Bills of Quantities, which prices shall be full compensation for furnishing all materials, for all labour, equipment tools, supplies and all other items necessary for the proper completion of the Works as specified and for testing, installation and putting into operation.

No materials will be supplied by the Ministry of Communications or the Employer.

The Contractor shall provide all the required materials. Materials manufactured in Kuwait such as uPVC duct / pipe, G.I. duct / pipe, Steel duct / pipe, MH cover, HH cover, Spacers for ducts / pipes, ready mixed concrete etc. shall be used. The Contractor is responsible for the quality of the materials supplied, and their continuous and timely delivery.

The materials for civil work such as sand, cement, aggregate cement blocks, iron bars, reinforcement, waterproofing material, water etc. shall be considered as part of the installation cost.

2101.14.2 Items in the Bill of Quantity

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2101.1	Manholes (size or type)	nr
2101.2	Handholes (size)	nr
2101.3	uPVC ducts / pipes (size, configuration, encased/directly buried)	m
2101.4	Lead-in ducts / pipes	m
2101.5	4 Way HDPE subducts	m
2101.6	Distribution Cabinets (provisional)	nr

SECTION 22: SANITARY SEWER WORKS

2200 - GENERAL

2200.01 DRAWINGS AND SPECIFICATIONS

Unless otherwise shown on the Drawings or in the Contract Documents, the latest issue of the Standard Drawings and Specifications of the Ministry of Public Works, Sanitary Sewer Section, shall apply to work carried out under this Section.

NOTE: The Contractor shall be responsible for liaison with the Ministry of Public Works, Sanitary Sewer Section and for all costs incurred in obtaining the latest versions of the above Specifications and Drawings and for ensuring that work and materials comply with the relevant parts of those Specifications and Drawings.

2201 - REMOVAL OF EXISTING PAVEMENT AND OBSTRUCTIONS

2201.01 MEASUREMENT AND PAYMENT

2201.01.1 Basis of Measurement and Payment

Measurement and payment for removal existing pavement and obstruction shall be measured and paid as described in Clause 207.08 of Section 2 (Earthworks) of these Specifications. Sanitary Sewer Items under this Clause will be paid as part of this Bill No 22 (Sanitary Sewer Works).

2201.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2201.1	Removal and disposal of pipelines	m
2201.2	Removal of manholes (concrete/blockwork)	nr

2202 - EARTHWORKS

2202.01 MEASUREMENT AND PAYMENT

2202.01.1 Basis of Measurement and Payment

Measurement and payment for removal Earthworks shall be measured and paid as described in Clause 605 of Section 6 (Stormwater Drainage) of these Specifications.

2202.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2202.1	Pipes Trench Excavation (diameter, depth stage)	m
2202.2	Removal and Reinstatement of Existing Pavement Courses	sq.m
2202.3	Removal and Reinstatement of Existing Precast Concrete Paving	sq.m
2202.4	Removal and Reinstatement of Existing Street Furniture (Type)	nr
2202.5	Excavation for other Miscellaneous Works	cu.m

2203 - PIPE LAYING AND CONNECTIONS

2203.01 MEASUREMENT AND PAYMENT

2203.01.1 Basis of Measurement and Payment

Measurement and payment for pipe laying and connections shall be measured and paid as described in Clause 606 of Section 6 (Stormwater Drainage) of these Specifications.

2203.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2203.1	Pipes Supply and Installation (Diameter, Material)	m

2204 - CONCRETE WORKS FOR PIPE LAYING

2204.01 MEASUREMENT AND PAYMENT

2204.01.1 Basis of Measurement and Payment

Measurement and payment for concrete works for pipe laying shall be measured and paid as described in Clause 609 of Section 6 (Stormwater Drainage) of these Specifications.

2204.01.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2204.1	Plain Concrete (class, location)	cu.m
2204.2	Reinforced Concrete (class, location)	cu.m
2204.3	Pipe Connection to Existing Drain (Type)	nr

2205 - CONCRETE WORKS FOR MANHOLES AND CHAMBERS

2205.01 CONSTRUCTION

Manholes and chambers shall be constructed to the details shown on the Drawings. Concrete works shall be in accordance with Section 5 (Concrete Works) of these Specifications and Sulphate resisting cement shall be used in all cases.

2205.02 MEASUREMENT AND PAYMENT

2205.02.1 Basis of Measurement and Payment

Measurement and payment for concrete works for manholes and chambers shall be measured and paid as described in Clause 610 of Section 6 (Stormwater Drainage) of these Specifications.

2205.02.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2205.1	Manhole (Type)	nr
2205.2	Chamber (Type)	nr

2206 - PIPELINE CONSTRUCTION BY NON-DISRUPTIVE METHODS (MICROTUNNELLING)

2206.01 CONSTRUCTION

Pipeline construction by non-disruptive methods (microtunnelling) shall be as specified in Clause 614 of Section 6 (Stormwater Drainage) of these Specifications.

2206.02 MEASUREMENT AND PAYMENT

2206.02.1 Basis of Measurement and Payment

Measurement and payment for Pipeline construction by non-disruptive methods (microtunnelling) shall be measured and paid as described in Clause 614 of Section 6 (Stormwater Drainage) of these Specifications.

2206.02.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2206.1	Pipe supply and installation by NDM (material, diameter)	m

2207– TESTING INSTALLED PIPELINES

2207.01 MEASUREMENT AND PAYMENT FOR TESTING

Testing shall not be measured or paid separately. All labour, materials, equipment and associated work shall be considered as incidental to and included in the rates for pipe laying.

2208– MODIFICATION OF EXISTING MANHOLES

2208.01 MEASUREMENT AND PAYMENT

2208.01.1 Basis of Measurement and Payment

Measurement and payment for modification of existing manholes shall be measured and paid as described in Clause 611 of Section 6 (Stormwater Drainage) of these specifications.

2208.01.2 Items in the Bill of Quantities

Pay Item	Description	Unit of Measurement
2208.1	Raising manholes or the like (type and height raised)	nr
2208.2	Lowering manholes or the like (type)	nr
2208.3	Grouting of abandoned drainage pipes (diameter)	nr

2209– PROTECTION OF STRUCTURES

2209.01 GENERAL

All structures under Clauses 2205, 2208 of these Specifications shall be protected as specified under Clauses 516 and 517 of Section 5 (Concrete Water) of these Specifications.

2209.02 MEASUREMENT AND PAYMENT

2209.02.1 Basis of Measurement and Payment

The method of measurement for concrete protection water shall be as specified in Clauses 516.06 and 517.05of Section 5 (Concrete Works) of these Specifications

2209.02.02 Items in the Bill of Quantities

Pay Item	Description	Unit of Measurement
2209.1	Concrete protection by membrane	sq.m
2209.2	Concrete protection by painting	sq.m

SECTION 23: MECHANICALLY STABILISED EARTH RETAINING WALLS

2300 - DESCRIPTION

2300.01 GENERAL

This work shall consist of constructing retaining walls using a proprietary system of precast concrete panels restrained by tie-backs into a compacted earth fill, as approved by the Engineer. They shall meet the requirements of AASHTO and be constructed in accordance with the manufacturer's drawings and specifications and be within the tolerances for lines, grades and dimensions shown in the Contract Documents or as established by the Engineer. The wall shall consist of a type of mechanically stabilized earth wall system acceptable to the Engineer, and which must be constructed by a specialized firm having a minimum of five years of documented successful experience in the design and construction of such wall systems. The Contractor shall provide a complete set of typical detailed shop drawings and complete specifications of the proposed wall system for the approval of the Engineer 90 days prior to ordering materials to construct these walls.

The design shall meet the requirements of AASHTO and address the climate and soil conditions existing in Kuwait and provide a minimum design life of seventy-five years. The specification as presented to the Engineer shall also state any requirements for the thickness of reinforcing strips, reinforcing geogrids, and/or limitations on the backfill used in the structure to ensure the design life. The final thickness shall be subject to the approval of the Engineer.

The terms "drawings", "detailed plans", "shop drawings" and similar statements as used in this Section 23 shall mean the shop drawings as prepared by the Contractor and submitted to the Engineer for approval in accordance with the Tender Documents.

The term "reinforced earth components" shall be deemed to have the same meaning as "mechanically stabilized earth retaining walls".

The works shall include the following:

a. Reinforced Earth components (panels, high adherence galvanized steel strips, rubber strips, polymer geogrids (e.g. polyethylene / polypropylene geogrids), non metallic friction ties, connection and joint materials)
b. Selected backfill
c. Precasting panels
d. Leveling pads (Footing or Foundation)
e. Wall erection
f. Coping
g. Bituminous protection coating to concrete surfaces in contact with earth
h. Monitoring

Only materials supplied by accredited sub-contractor or supplier shall be used as Reinforced Earth Components.

The Contractor shall submit for prior approval a detailed Method Statement that describes all means, method and techniques to be adopted for construction and installation of the "mechanically stabilized earth retaining walls". The Method Statement shall include details of equipments to be used, method of installation of each reinforced earth components taking into consideration the manufacturer's recommendations, backfill materials to be used backside of wall, testing and report procedures, work program and any other information required by the Engineer.

2300.02 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this Specification.

ASTM

A 36M	(AASHTO M183) Structural Steel
A 123M	Zinc (Hot Galvanized) Coating on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates Bars and Strips
A 153M	Zinc Coating (Hot Dip) on Iron and Steel Hardware
A 325	High Strength Bolts for Structural Steel Joints Including Suitable Nuts and Plain Hardened Washers
A 615	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
A 1011M	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
D 1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
D 2049	Standard Test Method for Relative Density of Cohesionless Soils
D 2850	Standard Test Method for Unconsolidated-Undrained Triaxial CompressionTest on Cohesive Soils
D 4354	Practice for Sampling of Geosynthetics for Testing
D 4759	Practice for Determining the Specification Conformance of Geosynthetics
D 5262	Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics
D 6637	Standard Test Method for Determining Tensile Properties of Geogrids by the Single Rib or Multi-Rib Tensile Method.
G51	Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing
G 57	Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

AASHTO

T 90	Determining the Plastic Limit and Plasticity Index of Soils
M 164	Standard Specification for High-Strength Bolts for Structural Steel Joints
M 232	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
T 26	Standard Method of Test for Quality of Water to be Used in Concrete
T 180	Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

Geosynthetic Research Institute (GRI)

GG2-87	Standard Test Method for Geogrid Junction Strength
GG4-91	Determination of the Long-Term Design Strength of Geogrids
GG5-91	Standard Test Method for “Geogrid Pullout”

2301 - MATERIALS

2301.01 GENERAL

The Contractor shall make his own arrangements to provide the face panels, reinforcing and tie strips, fasteners, joint filler, and all necessary attachments as recommended by the manufacturer and approved by the Engineer.

Materials and construction of reinforced earth components shall comply with the stipulations of Clause 505 precast concrete of Section 5 (Concrete Works) of these Specifications.

2301.02 CONCRETE FACE PANELS

Concrete shall be Class K300 in accordance with Section 5 (Concrete Works) of these Specifications, except as specified herein.

All appurtenances and lifting and handling devices shall be set in place to the dimensions and tolerances shown on the approved shop drawings prior to casting.

i. Reinforcing steel shall comply with Clause 501.07 of these Specifications (ASTM A615 Grade 60).

ii. Concrete Finish – The concrete surface pattern and finish for the exposed faces shall conform to Clauses 504.05.1 and 504.05.2 of these Specifications. The rear face of the panel shall be roughly screeded to eliminate surface distortions in excess of 6.5 mm. The colour and texture of the finish shall be approved by the Engineer based on three trial panels provided by the Contractor prior to producing the final panels.

iii. Tolerances – All units shall be manufactured within the following tolerances:

   a. All dimensions within $\pm$5 mm.
   b. Angular distortion with regard to the height of the panel shall not exceed 7 mm in 2 m.

iv. Compressive Strength – Acceptance of the concrete face panels with respect to compressive strength will be determined in accordance with Clause 507 of these Specifications, except that a minimum of one set of test cubes shall be taken from each lot of 50 panels or part thereof.

v. Additional Compressive Tests: An additional 4 specimens shall be field cured in the same manner as the concrete facing panels. Compression tests on these specimens shall be used to determine the length of curing time required and acceptability. Panels will be accepted after 7 days, provided the compressive strength of field cured cubes exceeds 65% of the required 28-day strength. Panels with defects that indicate imperfect molding, honeycombing, or open texture concrete, or that do not correspond with the quality of the approved test panel will be rejected.

vi. Rejection – Units shall be subject to rejection by the Engineer if not in conformance with these Specifications or if any of the following defects are evident by visual inspection:

   a. Defects that indicate imperfect molding.
   b. Defects indicating honeycombed or open texture concrete.

vii. Marking – The date of manufacture shall be clearly scribed on the rear face of each panel.

viii Handling, Storage and Shipping – All units shall be handled, stored and shipped in such manner as to eliminate the danger of chipping, cracks, fractures and excessive bending stresses. Panels in storage shall be supported on firm blocking located immediately adjacent to tie strips or toggles to avoid damage to these tie strips and toggles. Any panels, including fastening hardware, damaged during handling, storage, or shipping shall be rejected by the Engineer.

ix. Joint spacing and details for expansion, contraction, construction and control joints in the coping and the concrete barrier parapet shall be as recommended by the manufacturer and as approved by the Engineer.

x. Test Panels: The Contractor shall construct and submit at least 3 test panels. The materials, including formwork, used in construction of all test panels shall be as for those proposed for use in the Works. The test panel finish shall be approved by the Engineer prior to production of any panels for incorporation in the Works. The rear face of each panel shall have a dense, rough texture without honeycombed areas. The approved panels shall remain available on Site throughout the duration of the Contract, as a standard for judging the completed works.

2301.03 CONCRETE FOOTINGS

The class of concrete shall be as shown on the approved shop drawings and shall conform to Section 5 (Concrete Works) of these Specifications.

2301.04 STEEL REINFORCING AND TIE STRIPS

Tie strips shall be shop fabricated of hot rolled steel conforming to the minimum requirements of ASTM A-1101M, Grade 36 or equivalent. Reinforcing strips shall be hot rolled steel and shall conform to the requirements of ASTM A-36M or equivalent. The tie strips and reinforcing strips shall be hot dip galvanized conforming to the requirements of ASTM A-123M.

The properties of the backfill material to be used shall be one of the main factors in determining the strip

thickness required to meet the specified design life.

Prior to galvanizing, the tie strips and reinforcing strips shall be cut to length and tolerances shown on the detailed plans and the holes for bolts shall be punched in the locations shown. All reinforcing and tie strips shall be carefully inspected to ensure they are true to size and free from defects that may impair their strength and durability. The Contractor shall furnish the Engineer with a Certificate of Compliance certifying that these materials comply with the applicable Specifications.

Physical and Mechanical Properties: Reinforcing strips and tie strips shall have a minimum yield point of 2,400 kg/sq.cm (235 MN/sq.m); minimum tensile strength of 3,700 - 4,500 kg/sq.cm (363-441 MN/sq.m); 0.06% maximum phosphorus; and 0.05% maximum sulfur. The weight of zinc coating shall be not less than 500 gm/sq.m.

2301.05 REINFORCING (POLYMER) GRIDS

General: Shapes and dimensions of these elements shall conform to the dimensions and tolerances shown on the Drawings. The geogrid materials shall conform to the requirements of Clause 211 of Section 2 (Earthworks) of these Specifications, unless otherwise specified in this Section for the same property, then the requirements provided in Section 23 (Mechanically Stabilized Earth Retaining Walls) will prevail.

Grid reinforcing elements shall be manufactured by stretching a punched polyethylene sheet in one direction under controlled conditions to produce a high tensile strength orientated structure.

Mechanical Properties: The grid shall have a short term strength of not less than 79 kN/m width, determined from tensile testing at 20 degrees Celsius under a constant rate of extension of 50 mm/minute. For each batch of reinforcing material delivered to Site, or at such other times as may be required by the Engineer, the Contractor shall submit a test certificate from an approved independent testing laboratory confirming that the required strength characteristics have been met. The 120 year characteristic strength shall be not less than 29 kN/m width.

Physical Properties: The weight of grid shall not be less than 0.85 kg/sq.m. It shall be immune to attack from ultra-violet light for a minimum period of 3 years and shall be immune to attack from all chemicals naturally found in soils and to biological attack from micro-organisms. The Contractor shall furnish the Engineer with the manufacturer's warranty to this effect. The minimum roll width shall be 3.5 m. Methods of joining reinforcing material shall be approved and in accordance with the manufacturer's instructions.

Upon manufacture, the reinforcing elements shall be placed in approved wrapping material which shall prevent ultra-violet light from reaching the reinforcing elements. The reinforcing elements shall be identified with their date of manufacture. Upon delivery to Site the Contractor shall provide the Engineer with copies of the manufacturer's certificates clearly stating the dates of manufacture of the reinforcing elements. No reinforcing elements shall be incorporated into the Works if at the time of proposed incorporation the elements are more than three years old.

2301.06 FASTENERS

Fasteners: Bolts and nuts shall have hexagonal heads and conform to AASHTO M 164, Type 2, except as modified hereunder. Bolts shall be 12 mm in diameter, 30 mm in length with 20 mm of thread length. Fasteners shall be hot dip galvanized to AASHTO M 232, Class C. Bolts shall have a minimum yield point of 6,400 kg/sq.cm (627 MN/sq.m); minimum tensile strength of 8,000 kg/sq.cm (784 MN/sq.m); and minimum elongation of 12%. Fasteners may be made of polymers according to geogrid manufacturer’s specifications. Their use is subject to the approval of the Engineer.

2301.07 NON METALLIC FRICTION TIES AND FIXINGS

The stabilized earth wall structure shall be reinforced with friction strips of polyethylene coated polyester fiber strips or similar material approved by the Engineer. The reinforcing strips shall have the ultimate strength indicated on the Drawings, and manufacturer’s test certificates shall be provided to verify this.

Reinforcing strips shall be fixed to the facing panels using plastic coated steel anchor loops and toggles, unless otherwise noted on the approved shop drawings and in accordance with approved samples. The Contractor shall furnish the Engineer with a Certificate of Compliance certifying that these materials comply with the applicable Specifications.

2301.08 JOINT FILLER (FOR USE WITH CONCRETE FACE PANELS)

i. Filler for vertical joints between panels shall be flexible open cell polyethylene foam strips, unless otherwise noted on the approved shop drawings.

ii. Filler for horizontal joints between panels shall be resin bonded cork filler conforming to ASTM D 1752 (Type II) unless otherwise noted on the approved drawings.

2301.09 SELECTED GRANULAR BACKFILL MATERIAL

Reinforced Earth selected backfill material can be either natural soil or material of industrial origin. Backfill shall not contain chalk, unburnt colliery shale, pulverized full ash, organic or other materials which, in the opinion of the Engineer, would result in the structure becoming unfit for its intended use. Prior to placing the granular fill, the Contractor shall certify to the Engineer that the material conform to the requirements as per the Specifications and Drawings.

Selected Filter Material for Drainage Layers: Filter backfill material shall conform to the relevant requirements of Clause 209 "Pervious Backfill" of Section 2 (Earthworks) of these Specifications.

2301.09.1 Backfill for Steel Reinforcing Strip System

The selected fill shall conform to the following gradation and shall have a coefficient of uniformity not less than 2 ($C_u=D_{60}/D_{10} \geq 2$):

Sieve Size	**% Passing**
250 mm (10 in)	100
100 mm (4 in)	75-100
0.075 mm (No. 200)	0-15

The Contractor may request that the acceptance limits be increased for material not meeting the requirement for % passing a 0.075 mm sieve provided an analysis is submitted, showing that the material passing the 0.075 mm sieve is less than 10% smaller than 0.015 mm, or alternatively that the material is less than 20% smaller than 0.015 mm and the angle of internal friction as determined by ASTM D 2850 is 25 degrees minimum.

Materials shall have a minimum resistivity when measured in accordance with ASTM G 57 of 5,000 ohm-cm.

Materials having a resistivity less than the above but greater than 1,000 ohm-cm may be acceptable provided that the pH value of the material measured in water extracted from a water-soil mixture is between 5 and 10 when tested in accordance with ASTM G 51, and that the water extracted from the water-soil mixture has a chloride content of less than 200 ppm and a sulphates content of less than 1,000 ppm when tested in accordance with AASHTO T 26.

The total sulphide content of the fill shall be less than 0.3 gm/kg.

Organic matter content, (difference between total carbon content and mineral carbon content) shall not be greater than 100 ppm.

If required by the Engineer, the Contractor shall carry out a test for Biochemical Oxygen Demand (BOD). The BOD value shall not exceed 0.004 gm/litre.

2301.09.2 Backfill for Reinforcing Polymer Grid System

Frictional Fill: This material shall contain a maximum of 10% passing the 0.075 mm (No.200) sieve.

Gradation Requirements: Backfill material shall conform to the following gradations:

Sieve Size	**% by weight Passing (Frictional Fill)**	**Max % by weight Passing (Cohesive Fill)**
125 mm (5 in)	100	100
90 mm (3.6 in)	85-100	85
9.5 mm (3/8 in)	25-100	25

0.600 mm (No. 30)	10-65	10
0.075 mm (No. 200)	0-10	10

Liquid and Plastic Limits: The portion of fill material passing the 0.425 mm (No.40) sieve shall have a liquid limit (L.L.) not exceeding 45% and a plasticity index (P.I.) not exceeding 20%.

2302 - CONSTRUCTION REQUIREMENTS

2302.01 WALL EXCAVATION

Structure excavation shall be in accordance with the requirements of Clause 208 of Section 2 (Earthworks) of these Specifications. Limits and construction stages shall be as shown on the Drawings.

2302.02 FOUNDATION PREPARATION

The foundation for the structure shall be graded level for a width equal to or exceeding the length of reinforcing material or as shown on the Drawings. Prior to wall construction, except where constructed on rock, the foundation shall be compacted with a smooth wheel vibratory roller.

Any foundation soils found to be unsuitable shall be removed and replaced in accordance with the procedures in Section 2 (Earthworks) of these Specifications.

When concrete face panels are specified, at each panel foundation level a concrete leveling footing shall be provided as shown on the Drawings. The footing shall be cured a minimum of 24 hours before placement of wall panels.

2302.03 ERECTION OF CONCRETE FACE PANELS

Precast concrete panels shall be aligned vertically using inserts cast into the top edge of panels. Panels shall be placed in successive horizontal lifts in the sequence shown on the approved drawings as backfill placement proceeds. As fill material is placed behind a panel, the panels shall be maintained in vertical position by means of clamps placed at the junction of adjacent panels and temporary wooden wedges placed in the horizontal or vertical joint at the junction of the two adjacent panels on the external side of the wall. External bracing may also be required for the initial lift. Vertical tolerances (plumbness) and horizontal alignment tolerances shall not exceed 25 mm when measured along a three meter straight edge. The maximum allowable offset in any panel joint shall be 25 mm. The overall vertical tolerance of the wall (plumbness from top to bottom) shall not exceed 25 mm per three meter of wall height.

2302.04 BACKFILL PLACEMENT

Backfill placement shall closely follow the erection of each lift of panels. The filling material will be graded and compacted before the placement of a new layer. The gradation of the selected granular backfill should be tested periodically during construction to assure compliance with Specifications. This gradation testing should be performed, at least once for every 500 cubic meter of material placed and/or whenever the appearance or behavior of the material changes noticeably. Material shall be laid with layers of uniform thickness not exceeding 150 mm, taking care to avoid segregation and water content variations.

Backfill shall be placed in accordance with Clause 208 of Section 2 (Earthworks) of these Specifications and compacted in accordance with the requirements shown below and on the Drawings. The maximum compacted lift thickness shall not exceed 150 mm and shall closely follow panel erection. The Contractor shall decrease this lift thickness if necessary to obtain the specified density.

At the end of each day’s operations, the Contractor shall shape the last level of backfill so as to permit run-off of rainwater away from the wall face.

Backfill outside roadway embankment areas shall be compacted to at least 90% AASHTO T 180 maximum density. Backfill within roadway embankment areas shall be compacted to 95% AASHTO T 180 maximum density except for backfill in subgrade zones which shall be compacted to 98% AASHTO T 180 maximum density.

The acceptance criteria for control of compaction shall be given by first the equivalent Relative Density as

determined by ASTM D-2049. Then by large-scale plate bearing test, which defines the type of the equipment, energy, lift thickness, etc. before beginning compaction, it is necessary to check that the moisture of the backfill material is the optimum (± 1.5%) value of modified AASHTO standard.

The compaction shall be carried out in such a way as to obtain a uniform density, rollers shall move to and from, always parallel to the wall and assuring that the overlapping between one run and the next shall not be less than 10% of the roller width. Backfill compaction shall be accomplished without disturbance or distortion of reinforcements and panels. Compaction in a strip one meter wide adjacent to the backside of the wall shall be achieved using an approved manually operated vibrating compactor.

If a reinforcing polymer grid and connections are used, they shall be handled and installed in accordance with the manufacturer's instructions and recommendations, copies of which shall be submitted to the Engineer before commencement of these works. The reinforcing grid shall not contain any cuts, kinks, twists, blisters or other defects which, in the opinion of the Engineer, would render it unsuitable for its intended use.

The 250mm wide backfill immediately behind the concrete face panel shall be of pervious material complying with and placed in accordance with Clause 209 of Section 2 (Earthworks) of these Specifications, with 150mm diameter perforated pipe at the bottom of the pervious fill, connected to the nearest drain.

2302.05 TRIAL EMBANKMENT

If shown on the Drawings, or if required by the Engineer, a trial embankment shall be constructed prior to start filling. The Contractor shall perform a full scale trial compaction test.

The allocation of the testing area, the system for the execution of the embankment and the testing program shall be fixed by the Engineer considering the following:

a. The equipment shall be the same to be used during all the construction.
b. The trial area shall be leveled and compacted, at approved locations or at locations adjacent to the Site.

The Engineer shall approve the materials and procedures on the basis of the trial results.

2303 - MONITORING

The scope of the required monitoring is related to verifying and certifying the compliance of the work with the design assumptions and construction procedures. In the meantime, some monitoring is devoted to guide the construction phases of the embankment in order to minimize the effect of settlements.

Those aspects will control the following:

- Selected backfill
- Settlements
- Horizontal displacements and overall stability
- Material durability

2303.01 SELECTED BACKFILL

Each layer must be subjected to control tests and meet the requirements before placement of the following layer.

The testing frequency, as specified, must be considered as a minimum and must be increased whenever the appearance and/or behavior of the material noticeably changes,

The location of testing and/or sampling will be determined by the Engineer, Test certificates in proper forms shall be promptly sent to the Engineer during the construction,

As indicated in the table under Clause 2303.05 of these Specifications, the frequency of the testing can be reduced after 5000 m^3. However, this can be done only when the gradation and physical properties of the material becomes practically constant.

2303.02 SETTLEMENTS

Survey of settlements will be done during the construction, particularly where the embankments lay on compressive soils intending to settle. Settlements shall be monitored by means of two different procedures:

- Topographic measurements on the wall face
- Vertical settlements on the foundation

Topographic measurements will be performed with leveling instruments and reference points installed on the wall face and with benchmarks located in stable areas.

An appropriate quantity of fixed reference points (steel plates) shall be installed on the panels every 7.5 meters elevation within each selected cross-section, For those measurements, a tolerance of ± 2 mm is required.

Foundation settlements shall be monitored using steel bars fixed on concrete at a distance of 1-2 meters from the wall facing. The vertical steel bar is to be protected by means of pipes. Measurements shall be taken from the top of the steel bars.

2303.03 HORIZONTAL DISPLACEMENTS

Possible horizontal displacements will be measured within the foundation soil and on the wall surface. Inclinometers shall be placed in similar locations to the settlements devices. They shall be installed within the solid bedrock. The measurements shall be frequent and related to the construction program. Possible horizontal displacements can easily be checked by a pendulum (plumb bob).

2303.04 DURABILITY

These investigations are only related to reinforcing strips and are generally carried out at the time of the regular detailed inspections of the structure, with a frequency of approximately 10 to 15 years. It may also be opportune to make such investigations if the structure has serious anomalies, the origin of which is likely to be sought in the mechanical failure of the strips.

The investigation method may vary according to whether the structure is or is not equipped with durability test samples. This monitoring and investigation is performed with special techniques and investigation method. In order to collect reliable and complete information in long term, it is vital that these operations be entrusted to a qualified specialist laboratory.

At every investigation, a certain number of test samples are extracted and the backfill sample is taken in the vicinity of these test samples. Durability test samples are samples of reinforcing strips of 60 cm long, of the same type as those used in the structure. They are placed in the backfill of the Reinforced Earth mass during the construction and can be extracted for the monitoring of corrosion phenomena.

As a general rule, durability test samples are located either at the lower part of the structure or, if the latter is at considerable height, at each change in the section of the strips.

At every investigation, one indicator is extracted from each zone in which test samples are located. In case of abnormal corrosion development, complementary investigations must be made; excavations must be opened for examining the first beds of reinforcements.

2303.05 TESTING FREQUENCY TABLE

TEST	Within first 5000 m^3	After first 5000 m^3
Grain Size	500	5000
Resistivity	500	5000
pH	500	5000
Soluble Salt Content	500	5000
AASHTO Mod.	500	5000
In-situ Density	250	1000
Plate Bearing	1000	5000
Water Content		

2304 - MEASUREMENT AND PAYMENT

2304.01 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Stabilized earth walls, including concrete face panels, footings, reinforcement, fasteners, joint filler, providing all materials to installation with respective materials testing and certificates, trial embankment, excavation, backfill, compaction, waterproofing, filter and drainage material, incidentals (such as light pole foundations, sign structure foundations, drainage structures and appurtenances), erection, testing, workmanship and construction to the Engineer's approval, shall be measured by the meter square for each wall.

Vertical limits of each wall for measurement purposes shall be between the top of the foundation of the stabilized earth wall and the top of the wall below coping, as shown on Figure 2304-01. Horizontal limits for measurement purposes shall be from end of wall to abutment or from end to end of walls.

Standard coping, including concrete, reinforcement, joint filler, incidentals and erection shall be measured by the meter run, complete and in place.

Concrete barrier parapet (on stabilized earth walls), including concrete, reinforcement, fasteners, joint filler and incidentals and erection shall be measured by meter run of concrete barrier, complete and in place.

The quantities, determined as provided above, will be paid for at the Contract price per unit of measurement, respectively, for each pay item as described below and included in the Bills of Quantities, which prices and payment will be full compensation for the work prescribed in this Section.

Payment for the Item, Stabilized Earth Walls, will be at the Contract price per meter square, measured as per Figure 2304-01 and described above. It shall include for the cost of any laboratory testing which may be required to be carried out to determine the properties of the backfill material to be used, which cannot be carried out with the equipment provided under Section 10 (Site Laboratories) of these Specifications.

Payment for the Item, Standard Coping (on stabilized earth walls) will be at the Contract price per meter run.

Payment for the Item, Concrete Barrier Parapet (on stabilized earth walls), will be at the Contract price per meter run.

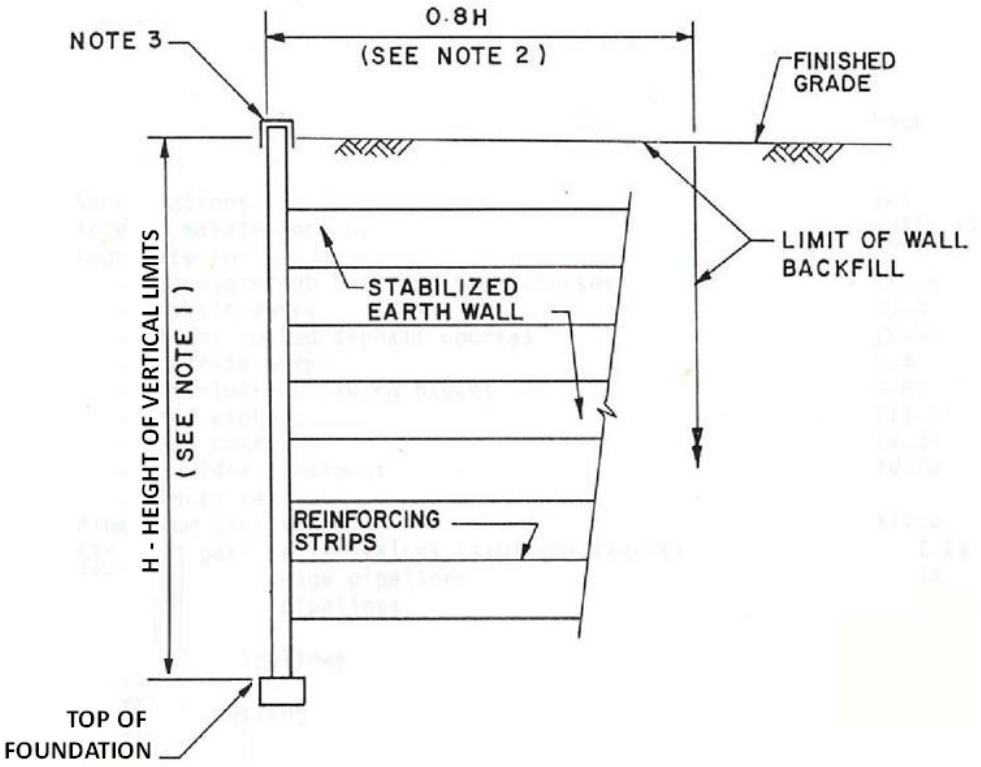


Figure 2304-01

Notes:

1. The height of the vertical limits, H, shall be measured from the top of the foundation to the top of wall below coping.
2. All backfill and filter required within 0.8H of the front face of the wall, including any wall footing excavations, shall be included in the price of the wall. Backfilling beyond 0.8H will be according to Clause 208.05 of Section 2 (Earthworks) of these Specifications, utilizing surplus, approved, suitable materials from excavations or from borrow pits as the case maybe.
3. See Structural Drawings for elevation at top of coping or concrete barrier, regardless if this fill, chosen by the Contractor, is similar to that used within 0.8H of the front face of the wall.
4. All concrete surfaces of panels in contact with the backfill or ground shall be waterproofed in accordance with Clause 517 of Section 5 (Concrete Works) of the Specifications.

2304.02 ITEMS IN THE BILL OF QUANTITIES

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2304.1	Stabilized Earth Walls	sq.m
2304.2	Standard Coping (on stabilized earth walls)	m
2304.3	Concrete Barrier Parapet (on stabilized earth walls)	m

SECTION 24: PILING

2400 - GENERAL

2400.01 DESCRIPTION

This work shall consist of furnishing and boring for or driving foundation piles or retaining wall's piles (secant) for structures in conformance with the details shown on the Drawings and as specified in these Specifications and the Contract Documents.

This Section specifies materials and workmanship for the manufacture, installation and testing of piling works. The type and size of piles to be used shall be as indicated on the Drawings.

The Contractor shall submit for prior approval a detailed Method Statement that describes all means, methods and techniques to be adopted for construction and installation of the bored or driven piles. The Method Statement shall include details of equipment to be used, method of excavation, slurries to be used, method of concrete placement quality control, testing and report procedures, work program, and any other information required by the Engineer.

The Contractor shall engage an experienced installer who has specialized in installing bored or driven piles (as per the design Drawings) similar to those required for each specific project. The Contractor shall assign a competent site supervisor to be in charge of pile construction and installation. The Contractor may execute the work by himself, provided he submits documentary evidence to prove that he has the experience and capability of installing bored or driven piles required as per the design Drawings and similar work, carried out successfully, in the past.

The Contractor shall submit one week prior to commencement of piling works his Quality Plan for the Works. Quality Assurance and Quality Control documentation shall be made available on request.

The Contractor shall inform the Engineer each day of the work program for the following day and shall give adequate notice of any intention to work outside normal working hours, at weekends and official holidays.

The Contractor shall submit to the Engineer, not later than noon of the next working day after the pile was installed, a comprehensive daily piling records. Any unexpected driving or boring conditions shall be noted in the records.

The Contractor shall protect structures, utilities, sidewalks, pavements and other facilities, on or adjacent to the Project site, from damage caused by settlement, lateral movement, vibration, and other hazards created by bored or driven pile operations. The Contractor shall submit his plans for making surveys and monitoring movements or vibration before the commencement of the piling works.

The Contractor shall carry out the piling work in such a manner and at such times to minimize noise and disturbance to the general public. If, during execution of the work, damage is likely to be caused to utilities or adjacent structures, the Contractor shall submit to the Engineer proposals for the repair or avoidance of such damage.

On completion of piling works, the Contractor shall deliver a schedule of installed piles giving a listing of toe levels.

2400.01.1 Standards and Codes

The following standards and codes in their latest edition shall be particularly applied to works covered by this Specification concerning the piling and testing of piles:

a. Standard Specification for Carbon Structural Steel: ASTM A36M.
b. Standard Specification for Welded and Seamless Steel Pipe Piles: ASTM A252
c. Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates: ASTM A283M
d. Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel: ASTM A572M
e. Standard Specification for Portland Cement: ASTM C150
f. Standard Specification for Aggregates for Masonry Grout: ASTM C404

g. Standard Specification for Round Timber Piles: ASTM D25
h. American Welding Society Standard: AWS D1.1
i. American Petroleum Institute (API) Standard: API RP 13B "Recommended Practice Standard Procedure for Testing Drilling Fluids"
j. Construction Industry Research and Information Association - CIRIA "Guide to the Construction of Reinforced Concrete in Arabian Peninsula"
k. Non-destructive, Sonic or Low-Strain Integrity Testing: ASTM D5882.
l. Standard Test Methods for Deep Foundations Under Static Axial Tensile Load: ASTM D 3689.
m. Standard Test Methods for Deep Foundations Under Static Axial Compressive Load: ASTM D 1143.
n. Specification for the Construction of Drilled Piers: ACI 336.1

2400.02 DEFINITIONS

Bored pile: a pile formed with or without a pile casing by excavating or boring a hole in the ground and filling with plain or reinforced concrete.

Secant pile: a pile which is designed to support soil and function as part of retaining structure.

Shaft diameter: diameter of the part of the pile between the pile head and the pile base shall be:

a. for bored piles constructed with casings, equal to the inner diameter of the casing.
b. for bored piles constructed without casing, equal to the maximum diameter of the boring tool.

Compression pile: a pile which is designed to resist an axial force such as would cause it to penetrate further into the ground

Tension pile: a pile which is designed to resist an axial force such as would cause it to be extracted from the ground.

Non-production pile: a pile that will not be incorporated in the Final Works.

Production pile: a pile designed to be incorporated in the foundation works of the structure.

Indicator pile: a non-production pile constructed and tested before the commencement of the main piling works for the purpose of establishing the suitability of the chosen type of pile and for establishing the required founding level, and to demonstrate the Contractor's construction methods, equipment, standards of workmanship, and tolerances.

Test pile: a pile to which loads are applied to determine the resistance deformation characteristics of the pile and the surrounding ground.

Static pile test: a loading test where a pile is subjected to chosen axial and/or lateral forces at the pile head for the analysis of its capacity

Maintained load test: a static load test in which a test pile has loads applied in incremental stages, each of which is held constant either for a defined period of time or until pile motion has virtually ceased or has reached a prescribed limit

Integrity test: a test carried out on an installed pile for the verification of soundness of materials and of the pile geometry

Sonic test: an integrity test of a pile where a series of sonic waves is passed between a transmitter and a receiver through the concrete of a pile and where the characteristics of the received waves are measured and used to infer continuity and section variations of the pile shaft

Sonic coring: a sonic integrity test of pile concrete carried out from core drillings in a pile shaft or from a preplaced tube system

Stabilizing fluid: water mixed with clay, bentonite or other material for the support of the excavation walls and the base in unstable ground

Boring fluid/mud: a suspension composed of water and bentonite, polymers or clay with or without cement and other additions, for stabilizing of bore hole walls and for flushing

Bentonite: a naturally occurring or manufactured sodium or calcium montmorillonite clay.

2400.03 MATERIALS

Piles shall consist of timber piles, precast prestressed or cast-in place concrete piles, steel piles or piles of such other materials as may be shown on the Drawings or required by the Contract Documents.

When the Drawings or Specifications permit the use of more than one type of pile, the same type of pile shall be used for all piles within each individual footing, unless otherwise permitted by the Engineer.

Concrete mixes, mixing and curing procedures shall be as specified in the relevant Clauses of Section 5 (Concrete Works) of these Specifications. Concrete mixes for use in piles shall be capable of maintaining a slump of 200 mm for 2 hours after placement. Concrete mixes shall be designed to resist aggressive soils and ground water if encountered in compliance with the requirements of the Construction Industry Research and Information Association – CIRIA "Guide to the Construction of Reinforced Concrete in the Arabian Peninsula".

Sand-Cement Grout shall consist of Portland cement manufactured according to ASTM C 150, Type I; and clean natural sand complying with ASTM C 404. Unless otherwise indicated, mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with sufficient potable water to permit flow during placement.

Slurry shall consist of pulverized sodium bentonite, pulverized attapulgite, or polymers, mixed with potable water to form a stable colloidal suspension; complying with ACI 336.1, and the values indicated for density, apparent viscosity (in centipoise), gel strength (in N/sq.m.), sand content, and pH.

Steel Pipe Casings shall comply with the requirements of ASTM A 283M, Grade C; or ASTM A 36M carbon-steel plate, with vertical joints full-penetration welded according to AWS D1.1.

Welds for fabricating steel piles and connecting steel pile lengths shall be as specified in the relevant Clauses of Section 5 (Concrete Works) and Section 12 (Metal Works) of these Specifications.

2400.04 DETERMINATION OF LENGTH

Foundation piles of any material shall be of such length as is required to develop the specified bearing value, to obtain the specified penetration and to extend into the cap or footing block as shown on the Drawings, or specified in the Contract Documents.

For driven piles, the Contractor shall furnish piles of sufficient length to obtain both the specified tip elevation and design load shown on the Drawings or specified in the Contract Documents. For cast-in-place concrete piles, the Contractor shall construct piles of such length to develop the compression nominal resistance and to obtain the specified tip elevation shown on the Drawings or specified in the Contract Documents.

At the Contractor's option, the Contractor may conduct, at his own expenses, additional foundation investigation, including installing and axial load testing additional non-production indicator piling. The Engineer shall approve locations of additional foundation testing. The Contractor shall notify the Engineer at least 5 working days prior to beginning additional foundation investigation.

Additional foundation investigation shall be completed prior to requesting revised specified pile tip elevations or modification to the installation methods specified herein.

Modification to the specified installation methods and specified pile tip elevation will not be considered at locations where lateral load demands control design pile tip elevations or when the Drawings state that specified pile tip elevation shall not be revised.

The pile structural capacity design is based on the nominal strength as defined in AASHTO. The nominal resistance of the pile, as shown on the Drawings, is the design capacity required to resist the factored axial load demands.

2400.05 INDICATOR PILE

The Contractor shall construct indicator piles of diameter and depth and at location indicated or if not indicated, as directed by the Engineer, of same diameter and depth as production piles indicated for the Project, located at least 3 diameters clear of production piles.

The Contractor shall install casing or use bentonite slurry and excavate, all as required for production piles. The Contractor shall also install steel reinforcement, fill with concrete, remove temporary casings, if applicable, and terminate indicator pile as instructed by the Engineer or indicated on Drawings, all using the same type of equipment that is to be used for the installation of production piles.

When the Engineer determines that an indicator pile does not meet requirements, the Contractor shall excavate for and cast another until indicator pile is accepted.

Indicator compression pile load testing shall conform to the requirements in ASTM Designation: D 1143.

Indicator tension pile load testing shall conform to the requirements in ASTM Designation: D 3689.

Upon completion of pile load testing, the head of indicator piles which are not to be incorporated in the foundation works shall be cut away, down to 1.5 meters below the cut-off level, and then backfilled using suitable material approved by the Engineer.

2400.06 DRIVING EQUIPMENT

Driven piles shall be installed with impact hammers that are approved in writing by the Engineer. Impact hammers shall be steam, hydraulic, air or diesel hammers. Impact hammers shall develop sufficient energy to drive the piles at a penetration rate of not less than 3 mm per blow at the specified bearing value.

Vibratory hammers shall not be used for installation of piles, unless otherwise shown on the Drawings or specified in the Contract Documents.

Hammers with an external combustion engine that are not single action shall have a transducer that records ram velocity.

Double acting diesel hammers with internal combustion engines shall have a transducer that records bounce chamber pressure.

For hammers with no visual way of observing the ram stroke, a printed readout showing hammer energy during driving operation shall be provided to the Engineer by the Contractor.

Steam or air hammers shall be furnished with boiler or air capacity at least equal to that specified by the manufacturers of the hammers to be used. The boiler or air compressor shall be equipped with an accurate pressure gauge at all times. The valve mechanism and other parts of steam, air or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed will be obtained. Inefficient steam, air or diesel hammers shall not be used.

When necessary to obtain the specified penetration and when authorized by the Engineer, the Contractor may supply and operate one or more water jets and pumps, or furnish the necessary drilling apparatus and drill holes not greater than the least dimension of the pile to the proper depth and drive the piles therein. Jets shall not be used at locations where the stability of embankments or other improvements would be endangered. In addition, for steel piles or steel shells, when necessary to obtain the specified penetration or to prevent damage to the pile during driving, the Contractor shall provide special driving tips or heavier pile sections or take other measures as approved by the Engineer.

2400.07 PREBORED HOLES

Piles, to be driven through embankment constructed by the Contractor, shall be driven in holes prebored or spudded through the embankment when the depth of new embankment at the pile location is in excess of 1.5 m. The hole shall have a diameter of not less than the greatest dimension of the pile cross section plus 150 mm. After driving the pile, the space around the pile shall be filled to ground surface with dry sand or pea gravel.

Material resulting from preboring holes shall be disposed of at a location to be approved by the Engineer.

2400.08 DRIVING

The Engineer shall be given 24 hours notice of commencement of the driving of the first pile.

The Contractor shall provide all necessary facilities to enable the Engineer to check driving resistances, sets and temporary compression.

The driving procedure shall be such as to avoid damage to the piles, and driving records shall be made for every pile. This record shall contain the weight and fall of the hammer or ram and the number of blows for each 0.25m of penetration. If an unexpected change in driving characteristics is noted, the Contractor shall inform the Engineer without delay.

Driving of each pile shall be continuous until the depth or set, as required by the design, has been reached and driving equipment that damages the piles shall not be used.

Piles shall be clearly marked with their number and overall length near the pile head using white paint. In addition, each pile shall be marked at intervals of 250mm along the top 3m of its length before being driven.

Driving heads or driving blocks which hold the pile in position directly under the hammer during driving shall be used. At all stages during driving and until incorporation in the superstructure, piles shall be adequately supported and restrained by means of leaders, trestles, temporary support or other guide arrangements to maintain the position and alignment and to prevent buckling.

In marine works, lengths which remain unsupported after driving shall be adequately restrained until incorporated into the permanent works. These constraint arrangements shall be such that no significant damage occurs to piles or their coatings.

Piles shall be driven in an approved sequence to minimize the detrimental effects of heave and lateral displacement of the ground. The sequence and method of piling including preboring (if necessary) shall limit uplift and lateral movement so that the final position of each pile is within the specified tolerances. At all times the deflections of each pile from its axis as formed shall not be such as to cause damage or impair durability of the piles or any structures or services.

The maximum permitted uplift of each pile due to any one pile driven within a pile centre to centre radius of eight pile diameters is 3mm unless it can be demonstrated that uplift exceeding this amount does not affect the ability of the pile to meet the Project's requirements. When a pile has risen as a result of adjacent piles being driven, the Contractor shall submit to the Engineer proposals for correcting this and its avoidance in subsequent work.

2400.08.1 Driving of Timber Piles

Timber piles shall be fresh-headed and square and when permitted by the Engineer, the heads of the piles may be protected by means of heavy steel or wrought iron rings. During driving operations timber piling shall be restrained from lateral movement at intervals not to exceed 6 m over the length between the driving head and the ground surface. During driving operations, the timber pile shall be kept moving by continuous operation of the hammer..

The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angles to the pile and hammer axis.

2400.08.2 Driving of Precast Prestressed Concrete Piles

The heads of concrete piles or shells shall be protected from direct impact of the hammer by a cushion driving block. The cushion shall be maintained in good condition during the entire driving operation. The cushion driving block shall be so arranged that any reinforcing bars projecting above the piles will not be displaced or injured in driving.

Precast prestressed concrete piles shall not be driven until the concrete cubes have achieved the specified characteristic strength and the pile has attained the strength to resist driving stresses, whichever is the greater.

Piles shall be driven to the position and line indicated on the Drawings. Piles materially out of line will be rejected. Rejected piles which interfere with the work shall be removed. Other rejected piles may either be removed or cut off and abandoned in place.

If repairs are needed during driving to the head of a pile, it shall be cut off square at sound concrete, and loose material removed by wire brushing, followed by washing with water. If the pile is to be subjected to further driving, the head shall be replaced by concrete of an approved Class.

Piles shall be lengthened, if required, by stripping off concrete from the reinforcement and lapping or coupling

additional steel in place. Laps shall be at least 40 x bar diameter. Couplers shall be approved by the Engineer.

Repaired or lengthened piles shall not be driven until the added concrete has reached the specified characteristic strength of the concrete of the pile.

2400.08.3 Driving of Steel Piles

Do not start pile-driving operations until earthwork fills have been completed and/or excavations have reached the platform level indicated on Drawings.

Sheet piles shall be pitched and supported as a panel before driving and securely interlocked. Piles shall not overlap each other and no pile in a panel shall be more than 1m in advance of another.

During driving, if approved, piles shall be lengthened by full penetration butt welding. Lengthening sections shall be of the same rolling. Longitudinal and spiral seam welding of cylindrical piles shall be staggered.

Sheet piles previously driven shall not be used in the permanent Works unless approved by the Engineer.

2400.09 SET OF THE PILE

Piles to be load tested shall be driven to the specified tip elevation.

Driven production piles shall penetrate at least to the specified tip elevation as shown on Drawings, unless otherwise permitted in writing by the Engineer in the event of refusal.

The set and temporary compression shall be measured and recorded for each pile at the completion of driving, unless otherwise stated in the Particular Specifications or on the Drawings.

The final set of the pile shall be recorded either as the penetration in millimeters per 10 blows or as the number of blows required to produce a penetration of 25mm.

When a final set is being measured, the following requirements shall be met:

i. The exposed part of the pile shall be in good condition without damage or distortion
ii. The dolly and packing, if any, shall be in sound condition,
iii. The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angles to the pile and hammer axis,
iv. The hammer shall be in good condition and operating correctly,
v. The temporary compression of the pile shall be recorded,

2400.10 CUT-OFF AND EXTENSION

2400.10.1 Timber Piles

After driving, the timber piles shall be cut off square to sound timber to within 5mm of the levels shown on the Drawings and the cut surface shall be heavily coated with preservative if and as specified for the initial treatment

Timber piles which are to be capped shall be accurately cut off so that true bearing is obtained on every pile without the use of shims. Piles inaccurately cut off shall be replaced. Splicing of timber piles will not be permitted, except by written permission of the Engineer. Timber piles under concrete footings shall be cut off at the designated elevations and anchor devices shall be installed as shown on the Drawings.

2400.10.2 Precast Prestressed / Cast-in-Place Concrete Piles

When the driving of a concrete pile has satisfied the Specification requirements, the concrete of the head of the pile shall be cut off at the level specified, reinforced bars projecting above this level shall be also as specified and anchored to the structure or pile cap as shown on the Drawings. If not indicated, the concrete pile shall be anchored to the structure by 100mm. Care shall be taken to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall cut away and the pile repaired in a manner to provide a full and sound section to cut-off level.

In the event that the concrete sound section is found below the cut-off level, pile anchor dowels shall be installed in holes drilled from the top surface of the concrete sound section.

When pile anchor dowels are used, the dowels shall be anchored in cast or drilled holes in the concrete pile with neat cement paste. If holes are to be drilled, they shall be drilled by methods that will not damage the concrete, reinforcement or prestressing steel. The diameter of the holes shall be the minimum consistent with placing the neat cement paste and dowel. The holes shall be free of dust and other deleterious material when the neat cement paste is placed. Sufficient paste shall be placed in the holes before the dowels are inserted so that no voids remain after the dowels are inserted. The dowels shall be left undisturbed until the paste has hardened. The cost associated with the drilling of holes, cleaning, placing the neat cement, procurement and installation of anchor dowels shall be borne by the Contractor

When concrete pile extensions are constructed on driven or cast-in-place concrete piles, the piles shall be cut off and extended with a reinforced concrete extension in conformance with the details shown on the Drawings.

The work of cutting off precast prestressed concrete piles shall be performed in such a manner as to avoid spalling or damaging the pile below cut-off level. In case of damage, the pile shall be replaced or repaired, to the satisfaction of the Engineer, by the Contractor at the Contractor's expense.

2400.10.3 Steel Piles

If pile heads are to be encased in concrete, the steel piles shall be cut off at the designated elevations, protective coating shall be removed from the surface of the pile heads and anchor devices shall be installed as shown on the Drawings.

If steel structure is to be welded to piles, the piles shall be cut square and to within 5mm of the levels specified.

All cut off lengths of piling shall become the property of the Contractor and shall be disposed of outside the worksite at a location approved by the Engineer.

2400.11 TOLERANCES

Vertical piles shall be constructed to remain within the following tolerances

i. Maximum Variation from Location: Not more than 75mm from the design center location, in any direction at the pile head.
ii. Out-of-Plumb (Verticality): 1in 75 deviation or not more than 1.5 percent of pile length, whichever is less
iii. Concrete Cut-Off Elevation: plus 25mm or minus 75mm from elevation indicated
iv. Bottom Area of Pile: Not less than 100 percent of pile area required
v. Shaft Diameter for Bored Pile: Not less than 100 percent or more than 110 percent of shaft diameter indicated.
vi. For steel piles and proprietary rolled sections, the deviation from straightness shall not exceed 1/1000 of the length of the section. Cylindrical steel piles shall not deviate from straightness by more than 1/600 for the length up to 10m and 1/1000 for lengths greater than 10m.
vii. The allowable Out-of Plumb deviation for raked piles shall be 1 in 25.
viii. No tolerance is allowed for shortening in the pile length or in the toe elevation.

2401 - TIMBER PILES

2401.01 DESCRIPTION

Timber piles shall be provided in one piece unless otherwise specified. During the execution of the piling works any changes to the supplied lengths shall be made known to the Engineer.

Timber piles shall conform to the requirements in ASTM Designation: D 25 for piles except as follows:

Butt and tip diameters shall be as specified in the following table:

Pile Length (m)	Butt Diameter		Tip Diameter Minimum (mm)
	Minimum (mm)	Maximum (mm)	
Under 12	300	500	200
12 to 16	300	500	175
16 to 23	325	500	175
23 to 27	325	500	150
27 and Over	325	500	125

Butt diameters are measured approximately one meter from butt.

The width of checks in untreated timber piles shall not exceed 10 mm. The width of checks in treated timber piles shall not exceed 10 mm after treatment or 13 mm immediately before driving.

2401.02 INSPECTION

The timber shall be new and free from defects, decay, large, loose or dead knots, undue shakes or excessive sap on more than one edge which may affect the strength or durability of piles.

The timber shall be free from rot, pests, fungal or pest attack and from defects not permitted for its grade.

The Contractor shall notify the Engineer of the delivery of timber piles to the Site or to the place of preservative treatment, and provide all labor and material to enable the Engineer to inspect each piece on all faces and to measure it at the time of unloading and immediately prior to driving.

Treated timber piles will be inspected by the Engineer after treatment.

2401.03 REQUIREMENTS

When preservative treatment of timber piles is required by the Drawings or specified in the Contract Documents, the treatment shall be creosote and shall conform to AASHTO.

Commercially treated piles from stock may be used for test piles.

Untreated and treated timber piles shall be of Douglas fir or Southern Pine timber and shall be clean peeled.

The natural moisture content of any untreated timber foundation pile when delivered to the worksite shall be not less than 18 percent at 50-mm depth.

Treated timber piles shall be driven within 6 months after treatment.

The natural moisture content of any timber pile to be treated shall be not less than 18 percent at 50 mm depth immediately prior to treatment. Inspection prior to treatment shall be by an established inspecting agency. Inspection reports shall be submitted with each individual shipment, and each pile shall be stamped with the date of inspection.

The timber shall be protected from the sun and rain by means of appropriate covering which will allows free circulation of air.

Timber piling shall be protected with steel straps placed at not more than 3-m centers along the pile. Five additional straps shall be placed on each pile; one each at 75 mm, 150 mm, 300 mm from the tip, and 2 within 600 mm of the butt.

Steel strapping shall be approximately 40 mm wide, 0.75-mm in nominal thickness and shall be fabricated from cold-rolled heat-treated high tensile strapping. Strapping shall develop a tensile strength of at least 22 kN. Straps shall be held in place with clips which are secured by crimping twice in the clip length with a notch-type sealer. The clip shall be approximately 65 mm long and fabricated from 0.75-mm thick steel. The clip joint shall

develop at least 75 percent of the strap tensile strength. Straps shall encircle the pile once and shall be tensioned as tight as possible either by hand operated or pneumatic tensioning tools.

All holes, cuts or daps in treated piles shall be treated with 2 applications of wood preservative conforming to AASHTO.

2401.04 TREATMENT OF TIMBER PILE HEADS

The heads of all treated timber piles which are not embedded in concrete shall be treated by one of the following methods, after the piles have been driven and cut off to the proper elevation:

- An application of wood preservative conforming to the AASHTO specifications shall first be applied to the head of the pile and a protective cap shall then be built up by applying alternate layers of loosely woven fabric and hot asphalt or tar similar to membrane waterproofing, using 3 layers of asphalt or tar and 2 layers of fabric. The fabric shall measure at least 150 mm more in each direction than the diameter of the pile and shall be turned down over the pile and the edges secured by binding with 2 turns of No. 10 galvanized wire. The fabric shall be wired in advance of the application of the final layer of asphalt or tar which shall extend down over the wiring.
- The sawed surface shall be covered with 3 applications of a hot mixture of 60 percent creosote and 40 percent roofing pitch, or thoroughly brush coated with 3 applications of hot creosote and covered with hot roofing pitch. A covering of 3.50-mm nominal thickness galvanized steel sheet shall be placed over the coating and bent down over the sides of each pile to shed water.

The method to be used shall be at the option of the Contractor, unless otherwise provided on the Drawings or in the Contract Documents.

The treatment of pile heads encased in concrete will not be required.

2401.05 PILE SHOES

The material and dimensions of the pile shoes shall be as shown on the Drawings.

The shoes shall be attached to the pile by steel straps fixed, spiked, screwed or bolted to the timber. The shoes shall be coaxial with the pile and firmly bedded to it.

2402 - PRECAST PRESTRESSED CONCRETE PILES

2402.01 DESCRIPTION

Precast prestressed concrete piles shall be constructed in conformance with the provisions in Section 5 - (Concrete Works) and Section 11 (Prestressed Concrete Works) of these Specifications.

When requested, the Contractor shall submit 2 sets of working drawings to the Engineer at the worksite for the Engineer's use in administering the Contract. The drawings shall show the pile dimensions, materials, prestressing methods, tendon arrangement and working stresses, including any addition or rearrangement of reinforcement from that shown on the Drawings.

Precast prestressed concrete piling will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least 10 days notice after delivery before commencing the fabrication of the precast prestressed concrete piling. Materials to be used shall be made available to the Engineer so they can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where the material is stored or where work on the material is being performed.

Concrete for precast prestressed concrete piles shall be placed in smooth mortar-tight forms, so supported as to prevent appreciable deformation or settlement during placing or curing. Unformed surfaces shall be finished to a smooth surface. When removed from the form, the pile shall present true, smooth, even surfaces free from honeycombs and voids and shall be so straight that a line stretched from butt to tip on any face will not be more than 25 mm from the face of the pile at any point.

When lifting anchors are used in precast prestressed concrete piles, the anchors shall be not less than 25 mm

clear from the reinforcement or prestressing steel in the pile.

Lifting anchors used in precast prestressed concrete piles shall be removed to a depth of at least 25 mm below the surface of the concrete and the resulting hole shall be filled with an approved cementitious repair mortar adhesive in accordance with the manufacturer's instructions before the piles are delivered to the job site.

The records of testing of the concrete and steel used in the piles shall be submitted.

2402.02 ORDERING OF PILES

The Contractor shall ensure that the piles to be incorporated into the permanent Works are available at the worksite in time.

2402.03 HANDLING

When raising or transporting precast prestressed concrete piles, the Contractor shall provide slings or other equipment to avoid any appreciable bending of the pile or cracking of the concrete. Piles materially damaged in handling or driving shall be replaced by the Contractor at the Contractor's expense. Precast prestressed concrete piles shall be so handled at all times as to avoid breaking or chipping the edges.

2402.04 PILE TOES

Pile toes shall be constructed so as to ensure that damage is not caused to the pile during installation.

2402.05 PILE JOINTS

Precast prestressed concrete piles shall be provided in one piece unless otherwise specified.

A jointed pile shall be capable of withstanding the same driving stresses as a single unjointed pile of the same cross-sectional dimensions and materials. The centroid of the pile joint shall lie within 5mm of the true axis of the pile element.

The welding of a joint to main reinforcement in lieu of a lapped connection with projecting bars affixed to the joint shall not be permitted.

2403 - CAST-IN-PLACE CONCRETE PILES

2403.01 DESCRIPTIONS

Cast-in-place concrete piles shall consist of one of the following:

- Bored holes filled with concrete.
- Steel shells driven permanently and filled with concrete

The diameter of a pile shall not be less than the specified diameter.

The boring of holes shall conform to the provisions in these Specifications.

Concrete filling for cast-in-place concrete piles is designated by compressive strength and shall have a minimum 28-day compressive strength as indicated on the Drawings. Concrete and Reinforcement shall conform to the provisions in Section 5, (Concrete Works) of these Specifications.

Cast-in-place concrete piles shall be constructed so that the excavation methods and the concrete placement procedures shall provide for placing the concrete against undisturbed material in a dry or dewatered hole.

The concrete filling for cast-in-place concrete piles shall be dense and homogeneous.

The concrete shall be placed as detailed under Clauses 2403.02.4 and 2403.03.4 below.

After placing concrete, the temporarily exposed surfaces of the cast-in-place concrete piles shall be cured in conformance with the provisions of Clause 504.06 "Curing" of Section 5 (Concrete Works) of these specifications.

2403.02 BORED HOLES FILLED WITH CONCRETE

2403.02.1 Execution.

Depending on the subsurface conditions, boring of pile holes can be executed by one of the following three methods:

1. Dry excavation method: where sufficiently stable soil or rock conditions are prevailing, which allows stability of the side walls without the use of any stabilizing means.

2. Excavation with slurry stabilizing fluid: where cohesionless/friable/collapsible or any unstable soil/rock conditions are encountered during excavation that would hinder the boring process and disturb the shape and alignment of the pile. The presence of groundwater, would also necessitate the use of slurry stabilizing fluid.

3. Excavation with temporary casing: This method can be used for the same conditions of those described for the slurry stabilizing fluid method. The option to use the full-depth temporary casing or the slurry stabilizing fluid method is left to the Contractor depending on the pile depth and on his favorite practice, as well as the feasibility of each method for the specific case, environmental regulations restrictions and other justifications that he may provide in his method statement.

A short length of temporary steel casings (1.5 – 3m) shall be furnished for all piles that are being executed either by "Dry Excavation" or by the "Excavation with Slurry" Methods and shall be placed tight in the pile holes to maintain the stability of the upper part of the pile borehole during excavation by controlling water or to prevent quick soil conditions or caving of the hole.

Piles shall be bored in an order and in such a manner that no significant damage is sustained by previously formed piles.

Care shall be taken during excavation to prevent disturbing the foundation material surrounding the pile. Equipment or methods used for excavating holes shall not cause quick soil conditions or cause scouring or caving of the hole.

After excavation is begun, the pile shall be constructed expeditiously in order to prevent deterioration of the surrounding foundation material from air slaking or from the presence of water.

The pile shall be bored to the depth shown on Drawings or beyond as deemed necessary and only after obtaining the Engineer's approval. No tolerance is allowed for shortening in the pile length or in the toe elevation. Any over excavation beyond the required pile depth shall be filled with the same concrete mix and concrete class of that used within the designated pile length, but after cleaning and inspecting the base of the shaft, as specified under Clause 2403.02.2 below. Cleaning and concrete filling of any unauthorized over excavation shall be done at the Contractor own expenses.

Excavation with slurry stabilizing fluid:

Where boring takes place through unstable water-bearing strata, a slurry stabilizing fluid shall be used in conjunction with the short length temporary casing to maintain the stability of the excavation and the sidewall of the boreholes until concrete has been placed.

When bored holes are to be stabilized with slurry stabilizing fluid, the slurry shall be maintained a minimum of 1.5m above ground-water level and above unstable soil strata to prevent caving or sloughing of hole. Excess slurry head is to be related to performance of on-going dewatering and to allow for fluctuations in depressed water levels.

Each batch of freshly prepared or reconstituted slurry shall be sampled and tested. Test results of samples and from excavation shall reflect the amount of contamination with saline ground water.

At least one sample from the base and one sample from the top of each hole shall be tested immediately prior to placing steel and concrete. The Engineer may subsequently vary frequency of sampling and testing when a working pattern has been established.

Tests and Compliance as per Table 2403.02.1: Values measured at 20 degrees Celsius.

Property	Test Method and Apparatus complying with the American Petroleum Institute (API) "Recommended Practice for Field Testing of Water-Based Drilling Fluids – API RP 13B-1":	Sample as supplied to excavation:	Samples from excavation prior to placing concrete:
Density	Mud balance	Less than 1.10 g/ml	Less than 1.15 g/ml
Fluid loss (30 min. test)	Low temperature test fluid loss	Less than 30 mil (0.762mm)	Less than 40 mil (1.016mm)
Viscosity	Marsh Cone	30 to 40 seconds	Less than 60
Plastic viscosity	Fann viscometer (material passing sieve No. 200)	Less than 10 cP	Less than 20 cP
Shear strength (10 min. gel strength)	Fann viscometer	4 to 25 N/m^2	4 to 25 N/m^2
Sand content	Sand screen set	Less than 1%	Less than 3%
PH	Electrical pH meter range 7 to 14	9.5 to 10.8	9.5 to 11.7

TABLE 2403.02.1: Tests and Compliance of Slurry.

Bored pile shaft shall be excavated and completely concreted on same day or the shaft shall be re-drilled, cleaned, re-circulated, de-sanded, or slurry replaced.

Excavation with temporary casing:

Temporary casing shall be watertight and of sufficient strength to withstand the loads from installation, removal, lateral concrete pressures and earth pressures. The casing shall be non-corrugated and the surfaces shall be smooth, free from distortion, clean, free from hardened concrete and shall be uniform section throughout their length.

The Contractor shall check the casing position for each pile during and immediately after placing of the casing. Any checks by the Engineer shall not relieve the Contractor of his responsibility.

The casing shall be removed while the concrete is being placed. In a dewatered hole the concrete in the casing shall be maintained at a level at least 1.5 m above the bottom of the casing or at a level above the bottom of the casing adequate to prevent displacement of the concrete by material from outside the casing, whichever is greater. Casing may be vibrated or hammered when required to assist in removal of the casing from the hole, to prevent lifting of the reinforcement and to prevent concrete contamination. The withdrawal of casings shall not leave voids or cause contamination of the concrete with soil or other materials.

2403.02.2 Cleanliness of Pile Bases and Inspection

On completion of boring, deteriorated foundation material, including material that has softened, swollen or degraded, shall be removed from the bottom of the hole and disposed of using appropriate methods, which shall be designed to clean while at the same time minimizing ground disturbance below the pile bases. The Contractor shall provide facilities required by the Engineer to facilitate inspection of the pile base.

Where used, slurry stabilizing fluid shall be maintained at such levels throughout and following the cleaning operation that stability of the pile hole is preserved.

Each pile bore which does not contain standing water or slurry stabilizing fluid shall be inspected from the ground surface prior to concrete being placed in it to ensure the base is adequately clean and that the shaft is stable and within the specified tolerances, Adequate means of lighting, measuring tapes and a means of measuring verticality shall be used.

2403.02.3 Reinforcement

The number of joints in longitudinal steel bars shall be kept to a minimum. Joints in steels reinforcement shall be such that the full strength of each bar is effective across the joint and shall be made so that there is no detrimental displacement of the reinforcement during the construction of the pile.

Where reinforcement is made up into cages, they shall be sufficiently rigid to enable them to be handled, placed

and concreted without damage.

Reinforcement shall be maintained in its correct position during concreting of the pile.

Unless otherwise specified, reinforcement shall extend to the base of the pile.

Spacers shall be designed and manufactured using durable materials which shall not lead to corrosion of the reinforcement.

Details of the means by which the Contractor plans to ensure the correct cover to and position of the reinforcement shall be submitted by the Contractor prior to commencement of the piling works.

After placing reinforcement and prior to placing concrete in the bored hole, if caving occurs or deteriorated foundation material accumulates on the bottom of the hole, as determined by the Engineer, the reinforcement shall be removed and the bottom of the bored hole cleaned.

Portions of the holes may be enlarged, backfilled with slurry cement backfill, concrete or other material, and rebored to the specified diameter to control caving. Backfill material at enlarged piles shall be chemically compatible with concrete and steel, shall be boreable and shall have the necessary strength required for the conditions.

Bore cuttings and material resulting from placing concrete in piles shall be disposed of at a location approved by the Engineer.

The reinforcement shall be placed and secured symmetrically about the axis of the pile and shall be securely blocked to clear the sides of the hole.

Migratory Corrosive Inhibitor (MCI-2005) is to be added to all concrete used in reinforced concrete piles in order to give a protection cover to the reinforcement. The material shall be incorporated in the concrete in strict accordance with the manufacturer's instructions.

2403.02.4 Placing Concrete

Before placing concrete, measures shall be taken to ensure there is no accumulation of silt or other material at the base of the boring.

A. Placing Concrete in Dry Boring

The method of placing shall be as to ensure that the concrete in its final position is dense and homogeneous. Concrete shall be introduced into the pile via a hopper and suitable length of rigid delivery tube to ensure that the concrete falls vertically and centrally down the shaft without segregation.

The pile heads shall be cast to a level above the specified cut-off so that, after trimming, a sound concrete connection with the pile can be made.

After each pile has been cast, any empty hole remaining shall be carefully backfilled as soon as possible with appropriate materials.

B. Placing Concrete under Water, in Temporary Casing or Slurry Stabilizing Fluid

The Contractor shall ensure that heavily contaminated slurry stabilizing fluid, which could impair the free flow of concrete from the tremie pipe, has not accumulated in the bottom of the hole.

A sample of slurry stabilizing fluid shall be taken from the bottom of the boring using an appropriate device and tested. If tests show the fluid does not comply with the limits stated (Table 2403.02.1), the fluid shall be wholly or partly replaced as appropriate before concrete is placed.

The concrete shall be placed without interruption. Records shall be kept of the workability of the approved mix. Under water or in slurry stabilizing fluid, the concrete shall be placed only by tremie. The tremie pipe shall be clean and watertight throughout and not less than 200mm internal diameter. Concreting shall start only after the tremie reaches the bottom of the pile shaft. Then, concreting will proceed with the end of tremie pipe kept immersed in the concrete for minimum depth of 2m. Method shall be used to prevent concrete segregation.

The pile heads shall be cast to a level above the specified cut-off so that, after trimming to remove all debris and

contaminated concrete, a sound concrete connection with the pile can be made

Temporary casings shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted.

After each pile has been cast, any empty hole remaining shall be carefully backfilled as soon as possible with appropriate materials

2403.02.5 Concrete Pile Head Cut-off and Waterproofing

Independent of the method adopted for cutting off the pile head (i.e. whether by means of hydraulic pile-breaker machine, light jackhammer or other approved means), the concrete of the head of the pile shall be cut-off to the level specified on Drawings or instructed by the Engineer. Reinforcing bars projecting above this level shall be as specified. Care shall be taken to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and the pile repaired to provide a full and sound section to cut-off level.

The pile head waterproofing details (wherever applicable) shall be as shown on the Drawings.

2403.03 STEEL SHELLS DRIVEN PERMANENTLY AND FILLED WITH CONCRETE

2403.03.1 Execution

Steel shells with cylindrical section shall be of sufficient strength and rigidity to permit driving, and to prevent distortion caused by soil pressures or the driving of adjacent piles until filled with concrete. The shells shall also be sufficiently watertight to exclude water during the placing of concrete.

The steel shells shall be installed as follow:

i. Install steel shells as excavation proceeds, to maintain sidewall stability
ii. Fabricate bottom edge of lowest shell section with a cutting shoe capable of penetrating the sub-formation and achieving a water seal
iii. Connect shell sections by continuous penetration welds to form watertight, continuous shell
iv. Remove and replace, or repair, shells that have been damaged during installation and that could impair strength of efficiency of driven piles
v. Fill annular void between shell and shaft wall with sand-cement grout
vi. Corrugated shells formed from zinc-coated steel sheet may be delivered in sections or panels of convenient length, and field connected according to manufacturer's written instructions.

2403.03.2 Inspection

After being driven and prior to placing reinforcement and concrete therein, the steel shells shall be examined for collapse or reduced diameter at any point.

If the pile hole does not contain standing water, the Contractor shall provide the Engineer with all required facilities including suitable means of lighting to facilitate inspection of the entire length of the shells and the pile base. Loose soil and debris accumulated at the base of the pile shall be removed.

Water which cannot be sealed or water flowing from the base of the pile shall be maintained in the pile hole.

2403.03.3 Reinforcement

The number of joints in longitudinal steel bars shall be kept to a minimum. Joints in steels reinforcement shall be such that the full strength of each bar is effective across the joint and shall be made so that there is no detrimental displacement of the reinforcement during the construction of the pile.

Where reinforcement is made up into cages, they shall be sufficiently rigid to enable them to be handled, placed and concreted without damage.

Reinforcement shall be maintained in its correct position during concreting of the pile.

Unless otherwise specified, reinforcement shall extend to the base of the pile.

Spacers shall be designed and manufactured using durable materials which shall not lead to corrosion of the reinforcement.

Details of the means by which the Contractor plans to ensure the correct cover to and position of the reinforcement shall be submitted by the Contractor prior to commencement of the piling works.

After placing reinforcement and prior to placing concrete in the steel shell, if deteriorated foundation material accumulates on the bottom of the steel shell, as determined by the Engineer, the reinforcement shall be removed and the bottom of the steel shell cleaned.

The reinforcement shall be placed and secured symmetrically about the axis of the pile and shall be securely blocked to clear the sides of the steel shell.

Migratory Corrosive Inhibitor (MCI-2005) is to be added to all concrete used in reinforced concrete piles in order to give a protection cover to the reinforcement. The material shall be incorporated in the concrete in strict accordance with the manufacturer's instructions.

2403.03.4 Placing Concrete

Before placing concrete, measures shall be taken to ensure there is no accumulation of silt or other material at the base of the pile's steel shell.

A. Placing Concrete in Dry Pile's Steel Shell

The method of placing shall be as to ensure that the concrete in its final position is dense and homogeneous. Concrete shall be introduced into the pile via a hopper and suitable length of rigid delivery tube to ensure that the concrete falls vertically and centrally down the shaft without segregation.

The pile heads shall be cast to a level above the specified cut-off so that, after trimming, a sound concrete connection with the pile can be made.

After each pile has been cast, any empty hole remaining shall be carefully backfilled as soon as possible with appropriate materials.

B. Placing concrete under water

The concrete shall be placed without interruption. Records shall be kept of the workability of the approved mix. Under water, the concrete shall be placed only by tremie. The tremie pipe shall be clean and watertight throughout and not less than 200mm internal diameter. Concreting shall start only after the tremie reaches the bottom of the pile shaft. Then, concreting will proceed with the end of tremie pipe kept immersed in the concrete for minimum depth of 2m. Method shall be used to prevent concrete segregation.

The pile heads shall be cast to a level above the specified cut-off so that, after trimming to remove all debris and contaminated concrete, a sound concrete connection with the pile can be made

After each pile has been cast, any empty hole remaining shall be carefully backfilled as soon as possible with appropriate materials.

2403.03.5 Concrete Pile Head Cut-off and Waterproofing

Independent of the method adopted for cutting off the pile head (i.e. whether by means of hydraulic pile-breaker machine, light jackhammer or other approved means), the concrete of the head of the pile shall be cut-off to the level specified on Drawings or instructed by the Engineer. Reinforcing bars projecting above this level shall be as specified. Care shall be taken to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and the pile repaired to provide a full and sound section to cut-off level.

The pile head waterproofing details (wherever applicable) shall be as shown on the Drawings

2404 - STEEL PILES

2404.01 DESCRIPTION

Steel piles shall include structural shape piles and pipe piles.

Structural shape steel piles shall be of the rolled section shown on the Drawings or of the section specified in

the Contract Documents and shall be structural steel conforming to the requirements in ASTM Designation: A 36/A 36M, or at the option of the Contractor, structural steel conforming to the requirements in ASTM Designation: A 572/A 572M.

Steel pipe piles shall conform to the following requirements:

i. Steel pipe piles less than 360 mm in diameter shall conform to the requirements in ASTM Designation: A 252, Grade 2 or 3.
ii. Steel pipe piles 360 mm and greater in diameter shall conform to the requirements in ASTM Designation: A 252, Grade 3.
iii. Steel pipe piles shall be of the nominal diameter and nominal wall thickness shown on the Drawings or specified in the Contract Documents.
iv. The carbon equivalency (CE) of steel for steel pipe piles, as defined in AWS D 1.1, Section XI5.1, shall not exceed 0.45.
v. The sulfur content of steel for steel pipe piles shall not exceed 0.05 percent.
vi. Seams in steel pipe piles shall be complete penetration welds and shall conform to the requirements in AWS D1.1 and amendments to AWS D1.1 in these Specifications and the Contract Documents. Incomplete penetration welds and defective welds of steel pipe piles shall be repaired or restored to achieve complete joint penetration groove welds.

Steel piles shall not be joined by welded lap splicing.

The manufacturer or fabricator of steel piles shall furnish a Certificate of Compliance stating that the piles being supplied conform to these Specifications and to the Contract Documents. The Certificate of Compliance shall include test reports for tensile, chemical, and any specified nondestructive tests. Samples for testing shall be taken from the base metal, steel, coil or from the manufactured or fabricated piles.

2404.02 SPLICING

Steel pile splices shall conform to the requirements in AWS D 1.1 and the Contract Documents. Structural shape steel piling splices shall be complete joint penetration groove welds. Steel pipe pile splices that are made at a permanent manufacture or fabrication facility, and that are made prior to furnishing the Certificate of Compliance, shall be complete penetration welds. Steel pipe pile splices that are made in the field shall be complete joint penetration groove welds.

When lengths of piles are to be butt-spliced on site, adequate facilities shall be provided for supporting and aligning them prior to welding such that the specified straightness criterion can be achieved.

Ends of steel pipe piling to be spliced that have been damaged during driving shall be removed to a sound and uniform section conforming to the tolerances for diameter, edge alignment and roundness required to meet the steel pile splice welding requirements. Pipe ends shall be field cut using automated guided cutting equipment. Manual flame cutting shall not be used.

2404.03 ORDERING OF PILES

The Contractor shall ensure that the piles to be incorporated into the permanent Works are available at the worksite in time.

2404.04 WELDING

Only qualified welders shall be employed on the works. Proof of welders' proficiency shall be made available to the Engineer on request.

The Contractor shall submit full details of the welding procedures and electrodes, with drawings and schedules as may be necessary.

Weld tests shall be performed by radiographic or ultrasonic methods as specified.

All work associated with welding shall be protected from the weather so that the quality of work meets the Contract's requirements.

2404.05 COATING

If steel piles are to be pre-coated, the preparation of surfaces and the application of the coating shall be carried out by experienced specialist labor having experience in the preparation of the surface and the application of the coating specified. All work associated with surface preparation and coating shall be undertaken inside a waterproof structure.

No coating shall be applied when the humidity could have an adverse effect on the coat.

The nominal thickness of the finished coating and if necessary of each coat shall be as specified. The average coat or finished coating thickness shall be equal to or greater than the nominal thickness. Where more than one coat is applied to a surface, each coat shall be, if possible, of a different color from the previous coat.

The finished coating shall be generally smooth, of dense and uniform texture and free from sharp protuberance or pin-hole. Excessive sags, dimpling or curtaining shall be retreated.

2404.06 MARKING, HANDLING AND STORAGE

Piles shall be clearly marked in white paint with their number and overall length. In addition, each pile shall be marked at intervals of 250mm along the top of 3m of its length before being driven.

All piles within a stack shall be in groups of the same length and on appropriate supports. All operations such as handling, transporting and pitching of piles shall be carried out in a manner such that no significant damage occurs to piles and their coatings

2405 - MEASUREMENT AND PAYMENT

2405.01 Method of Measurement and Basis of Payment

Setting up at each pile shall be measured by number.

Piles shall be measured in linear meters of actual length placed in the Permanent Works. The measured length shall be from the tip to the underside of the foundation, plus the penetration into the foundation specified on the Drawings.

Indicator piles that are constructed for the purpose of carrying out preliminary load tests shall be measured in linear meters of actual length, ordered and tested.

Payment shall be made at the rate included in the Bills of Quantities, which rate shall include full compensation for supplying and installing piles and for materials, labor, equipment, tools, records and other items necessary for the proper completion of the work.

2405.02 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2405.1	Setting up at each pile	nr
2405.2	Piling (type) (length) (size)	m
2405.3	Indicator piles (type) (length) (size)	m

2406 - PILE TESTING

2406.01 GENERAL

The Contractor shall submit Method Statement for each type of testing specified and provide details of specific techniques and processes proposed to be adopted for testing. The Method Statement shall include details of equipment and instrumentation, quality control and report procedures, work program, and any other information or special data required by the Engineer.

The Method Statement shall include details of loading and unloading as well as arrangement of reaction frame,

reaction piles or anchors. Due consideration shall be given to the effect of diameters of piles, socket length, type of bedrock, strain measurement in steel reinforcement and effect of dewatering. The structural analysis data shall be signed and sealed by the qualified professional engineer responsible for their preparation.

The Contractor shall submit daily work progress reports, identifying individual piles and type of testing carried out.

For non-destructive integrity testing, the Contractor shall qualify and engage an experienced independent testing agency, acceptable to the Engineer, who has specialized in non-destructive testing of bored or driven piles similar to that required for each specific Project.

Loading tests on indicator piles shall be completed before the production piles for that structure or specified control location are bored, cast, cut to length or driven.

Load test piles shall be installed with the same type of equipment that is to be used for installation of foundation piles.

The Contractor may use additional cement or may use Type III cement in the concrete for the anchor piles. The cost associated with such use will be borne by the Contractor.

The Contractor shall furnish labor, materials, tools, equipment, and incidentals as required to complete the pile load testing

2406.02 EXECUTION

2406.02.1 Preparation

The Contractor shall protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by bored or driven pile testing operations.

2406.02.2 Static-Load Testing

Static-load tests will be used to verify and confirm design load capacity of piles. Each pile diameter shall be tested as shown on the Drawings. The Contractor shall verify the feasibility of testing the loads corresponding to each pile diameter shown on the Drawings. The pile load tests shall not be carried out until all shrinkage of the concrete is complete. The reinforcement in the rock socket shall be strain-gauged to provide confirmation of the tensile force reaching the socket.

a. Dynamic formulas will not be permitted in place of load tests to determine bearing values of the piles.
b. Perform and complete testing, and obtain approval of pile test before proceeding with installation of permanent working piles in the Works.
c. Select the pile to be tested based on the results of pile integrity tests and pile construction records subject to the approval of the Engineer.
d. The same piles that will be tested in working compression loading should be among the selected piles for the working load test in tension.

The Contractor shall arrange and perform the static-load tests on piles as and when directed in the field.

The Contractor shall provide pile reaction frame, equipment and instrumentation with sufficient reaction capacity to perform tension tests and compression tests. On completion of testing, the Contractor shall remove testing structure, equipment and instrumentation.

The contractor shall notify the Engineer at least 48 hours in advance of performing tests and shall provide facilities to enable the Engineer to observe and check testing.

The test loads shall be applied by jacking against beams or equivalent reaction system. Center to center spacing of vertical reaction piles from a test pile shall be not less than 5 times the diameter of the test pile or the reaction piles or 2.5 m whichever is the greater.

The maximum loads to be applied in maintained load test shall be as follows:

a. For indicator piles in tension or compression load test, the Contractor shall apply test loads up to 2.5 times working load. The Contractor shall perform at least two indicator pile tension load tests and two indicator

pile compression load tests per type of piles, or as specified on the Drawings and in the Contract Documents.

b. For production piles in tension or compression load test, the Contractor shall apply test loads up to 1.5 times working load.

In the event of a pile continuing to displace under constant load before the maximum test load has been reached, take readings at 15 minute intervals for a period of one hour while the load is being maintained. Unload the pile in approximately 4 to 6 equal decrements at 15 minute intervals and allow recovering for 3 hours. Take one set of displacements readings after each decrement of load and a further set of readings at the end of the recovery period.

2406.02.3 Non-destructive, Low-Strain Integrity Testing

Non-destructive, integrity testing by sonic logging is to be performed on all piles, or as specified on the Drawings and in the Contract Documents, recorded, interpreted and reported by an approved experienced independent testing agency that has specialized in non-destructive testing of piles similar to that required for each specific Project. The Contractor shall submit proposed test result and report formats to the Engineer for approval before starting integrity testing.

The Contractor shall provide all available details of the ground conditions, pile dimensions and construction method to the testing agency before the commencement of integrity testing, in order to facilitate interpretation of test results.

The Contractor shall allow a minimum of seven days to elapse after casting before performing integrity testing on a pile.

The Contractor shall perform low-strain integrity testing according to ASTM D5882 by the stress wave method, seismic method or other method approved by the Engineer, based on the measurement of the axial shaft point mobility at the pile head.

Where the method of testing requires the positioning of sensing equipment on the pile head, the Contractor shall break down the pile head to expose sound clean concrete, free from water, laitance, loose, overspill or blinding concrete, and readily accessible for the purpose of testing.

All piles shall be subjected to Integrity Testing.

2406.03 TEST RECORDS

The Contractor shall maintain accurate test records for each pile, compiled and attested to by a qualified professional engineer, and submit to the Engineer at the conclusion of each pile test, pile number and date of testing; pile dimensions; type and method of pile testing and test results.

2406.03.1 Static load tests

The Contractor shall prepare static load test results in the form of tabulated field observations, including the Time vs. Displacement curves; Time vs. Load curves; Load vs. Displacement curves; Displacement vs. log time for each stage.

The Engineer will review test results and determine if a pile is acceptable, taking into account the acceptable total and differential displacements of the superstructure, the foundation geometry, the pile type and the soil conditions, etc. Test piles that show materially different displacement characteristics compared to indicator test piles will not be accepted.

2406.03.2 Non-destructive integrity testing

The Contractor shall submit preliminary test results to the Engineer within 24 hours of carrying out the tests.

The Contractor shall submit test reports to the Engineer within 10 days of the completion of each phase of testing.

Test reports should contain test results and conclusions, together with a summary of the method of interpretation including all assumptions, calibrations, corrections, algorithms and derivations used in the analyses. Where results are presented in a graphical form, the same scales are to be used consistently throughout

the report and the units on all scales clearly marked.

If any anomaly in acoustic signal test results indicates a possible defect in a pile, report such anomalies to the Engineer immediately. The Contractor shall demonstrate to the Engineer that the pile is satisfactory for its intended use or carry out remedial works to the Engineer's satisfaction.

The Contractor shall grout the sonic logging tubes only after piles have been demonstrated to the Engineer's satisfaction, to be satisfactory.

2406.04 MEASUREMENT AND PAYMENT

2406.04.1 Method of Measurement and Basis of Payment

Pile loading tests shall be measured per number.

Pile integrity tests shall be measured per number.

Payment shall be made for the completed work of "Pile Testing" at the rate included in the Bills of Quantities which rate shall include the full compensation for setting up, carrying out, reporting and for labor, equipment, tools, materials and other item necessary for the proper completion of the work.

2406.04.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2406.1	Static load testing of indicator piles (type) (length) (size)	nr
2406.2	Static load testing of production piles (type) (length) (size)	nr
2406.3	Non-destructive Integrity Test (type)	nr

SECTION 25: GROUNDWATER CONTROL

2500 - GENERAL

2500.01 SCOPE

At locations where the excavation extends below the ground water table, the Contractor shall provide a dewatering system which will effectively reduce the hydrostatic pressure and lower the groundwater levels below excavation levels, as required for the safe and proper excavation of the work and which will result in obtaining a stable, dry subgrade for the execution of subsequent operations. The work described under this Section of the Specifications augments the requirements specified under Clause 208.03 of Section 2 (Earthworks) of these Specifications

The Contractor shall design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control ground-water flow into excavations and permit construction to proceed on dry, stable excavation and subgrade.

The design of dewatering system specified above shall be prepared by and signed by a professional engineer specializing in this type of design work. The professional engineer shall be approved by the Engineer.

The Contractor shall maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrade and permanent structures is prevented. Surface water should be prevented from entering excavations by grading, dikes, or other means.

Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

The Contractor shall remove dewatering system when no longer needed and as instructed by the Engineer.

The Contractor shall plan his dewatering system and submit calculations in a way that water table should not drop sharply very close to the site limit in order not to affect the stability of neighboring buildings. The design shall include the measures taken to protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

The dewatering system and procedure shall be developed to ensure that adjacent buildings and roads are not adversely affected. Dewatering will change the stress conditions in the soils surrounding any of the excavations, due to lowering the groundwater levels and subsequent changes in pore water pressures. Therefore, adjacent foundation may be subject to settlements. When adjacent buildings fall within the dewatering zone, settlement-monitoring regime shall be established.

Where Dewatering is deemed, during the design, to adversely affect adjacent buildings, the extent of dewatering shall be minimized. This could be achieved in a number of ways, such as by using either diaphragm walls or contiguous/secant piled retaining walls. Should surrounding structures prove to be susceptible to settlement then the walls shall be constructed through a previously installed grout blanket just below foundation level. This will allow dewatering to take place without lowering the surrounding ground water. Whichever of these solutions is adopted it will be necessary to construct a bulkhead between this section and the next. This is probably best achieved by grouting the sands in-situ, thus forming a barrier to water migration. In order to protect the surrounding properties from movement due to deflection of the walls it may be necessary to provide temporary support with ground anchors.

It will be the Contractor’s responsibility to develop the details for safe dewatering. No damage to surrounding structures or roads is allowed. In such a case, the damage will be repaired at the expense of the Contractor. The Contractor shall carry out all measures necessary to protect the surrounding structures. The proposed measures shall be submitted to the Engineer for approval.

Prior to the commencement of any excavation or dewatering works, the Contractor shall facilitate and arrange a joint visual structural inspection of the adjacent existing buildings, properties or structures with an inspection team from the Municipality or its representative.

Any proposed dewatering system shall be compliant with all of Environmental Protection Authorities requirements.

The Contractor shall submit drawings to show arrangement, locations, and details of wells and well points; locations of headers and discharge lines; means of discharge and disposal of water; layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.

The Contractor shall propose a layout of piezometers and observation wells around the excavation at the site and monitor daily in order to predict unusual movement of groundwater outside the site limit.

Before starting excavation, the Contractor shall submit test results and computations demonstrating that dewatering system is capable of meeting performance requirements.

All submittals shall be in the English language.

2501 - EXECUTION

2501.01 PREPARATION

The Contractor shall install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

The Contractor shall not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Employer and authorities having jurisdiction. The Contractor shall provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

2501.02 INSTALLATION

The Contractor shall install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

Before excavating below ground-water level, the Contractor shall place system into operation to lower water to specified levels. The system shall operate continuously until drains, sewers, and structures have been constructed and fill materials have been placed, or until dewatering is no longer required.

The Contractor shall install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

Open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability is not permitted.

The hydrostatic head in water-bearing strata shall be reduced below subgrade elevations of foundations, drains, sewers, and other excavations. The piezometric water level shall be maintained at minimum of 500 mm below surface of excavation.

The Contractor shall dispose of water removed by dewatering in a manner that avoids inconvenience to others and endangering public health, property, and portions of work under construction or completed. The Contractor shall provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

The Contractor shall provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, the Contractor shall restore damaged structures and foundation soils at no additional expense to the Employer.

The Contractor shall remove dewatering system from Project site on when it is no longer needed and as instructed by the Engineer.

The Contractor shall plug or fill well holes with sand or cut off and cap wells a minimum of 1 m below overlying construction.

The Contractor shall promptly repair damages to adjacent facilities caused by dewatering operations.

2501.03 OBSERVATION WELLS AND SURVEYING

The Contractor shall provide, take measurements, and maintain at least the minimum number of observation wells or piezometers indicated and additional observation wells as may be required by authorities having jurisdiction.

The Contractor shall survey adjacent structures and improvements, employing a qualified professional engineer or land surveyor, establishing exact elevations at fixed points to act as benchmarks. Benchmarks and record existing elevations shall be clearly identified.

During dewatering, the Contractor shall regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. The Contractor shall promptly notify the Engineer if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

The Contractor shall observe and record daily elevation of ground water and piezometric water levels in observation wells.

The Contractor shall repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. Construction activities shall be suspended in areas where observation wells are not functioning properly until reliable observations can be made. Water is to be added or removed from observation-well risers to demonstrate that observation wells are functioning properly.

The Contractor shall fill observation wells, remove piezometers, and fill holes when dewatering is completed.

2502 - MEASUREMENT AND PAYMENT

2502.01 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Unless it is deemed to be included in the rates of structural excavation, dewatering works including dewatering before excavation, during excavation and construction, and removing the dewatering system, is given as an item.

Payment shall be made at the rate included in the Bills of Quantities and the rate shall include for designing the system, providing and installing wells, well points, header and discharge lines, filter material, pumping equipment, valves, appurtenances, flow measuring devices and the like; providing and installing observation wells and piezometers; providing survey for the adjacent structures; providing power, operating, maintaining and monitoring dewatering systems; providing and installing standby equipment and power on site; excavation and earthworks as necessary to accommodate the dewatering system; and to prevent surface water from entering excavations; disposing of ground and surface water; method statement, materials, calculations and drawings.

2502.02 ITEMS IN THE BILL OF QUANTITIES

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2502.1	Dewatering System	Item

SECTION 26: EXCAVATION SUPPORT AND PROTECTION

2600 - DESCRIPTION

2600.01 SCOPE

This work consists of special excavation support and protection systems specified for the Vertical Excavation under the major structures of the project, wherever deemed necessary. The work described under this Section of the Specifications augments the requirements specified under Clause 208.02 of Section 2 (Earthworks) of these Specifications.

The Contractor shall install excavation support and protection system and ensure not damaging existing buildings, structures, utilities, pavements and other site improvements, on or adjacent to the site, because of settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

The Contractor shall conduct geotechnical site investigation, when and where deemed necessary, to design the support system.

The support systems specified under this Section include diaphragm walls, secant pile walls, contiguous pile walls, steel sheet piles, bracings, and anchors and tie-backs with the associated grouting works.

The Contractor shall design, provide, install, monitor, and maintain an anchored and braced excavation support and protection system capable of resisting soil and hydrostatic pressure and supporting sides of excavations. Work also includes removing excavation support and protection systems when no longer needed, as agreed upon by the Contractor and the Engineer.

The design of the structure excavation support system specified above shall be prepared by and signed by a professional engineer specializing in this type of design work. The professional engineer shall be approved by the Engineer.

2600.02 GENERAL

The Contractor shall submit to the Engineer’s approval, appropriate calculations and analyses for each product component of each excavation support and protection system adopted, including but not limited the codes, standards and methods followed; the profile of the soil; lateral earth pressures for the full excavation depths, forces at various stages of support during installation and removal and concrete placement, the anticipated equipment loads, surcharge loads of any description, the maximum design loads to be carried by various member of the support system and strut preload forces.

The Engineer/Employer shall not be held responsible for any opinions or conclusions given in any factual and/or interpretative Site Investigation reports. During construction, the Contractor shall report immediately to the Engineer any circumstance which indicates that the ground conditions differ from those reported in the Site Investigation report.

The Contractor shall submit to the Engineer’s approval detailed drawings which show the extent of excavation at all points along the structure relative to adjacent properties, roads and services; and all relevant configurations and details relevant to the excavation support system.

The Contractor shall provide a detailed narrative describing means, methods and techniques to be adopted for construction and installation of special excavation support and protection systems, including details of equipment and instrumentation to be used, quality control, testing and report procedures, work program; contingency plan outlining procedures to be adopted if problems arise.

The support system shall be designed in such a manner that no raker struts or any other support members extend through surfaces exposed in the finished construction, and no shoring or bracing is placed under permanent structures.

Where a proposed system of tie-back anchors projects beyond the vertical projections of the Contract limit lines shown on the Drawings on to the adjoining property, the permission of the Owner shall be obtained in writing and such permission submitted to the Engineer at the time the shop drawings of the support system are

submitted.

The Contractor shall submit material certificates signed by manufacturers, certifying that material and product components comply with specified requirements and relevant ASTM or BS Standards.

All design methods for tie-back anchors, their applications and installation and testing procedures shall be in accordance with BS EN 1537 “Ground Anchorages”.

All submittals shall be in the English language.

Safety precautions shall comply with all current legislation. Work areas (jobsite) shall be fenced and barricaded from public access.

2600.03 MATERIALS AND WORKMANSHIP

All materials and workmanship shall be in accordance with the appropriate international Standards, Project Specifications, Codes of Practice and other specified standards current at the date of tender.

The Contractor shall submit, to the Engineer, the technical data sheets of all materials to be incorporated into the permanent works and obtain his approval before commencement of the works. Cement materials, steel reinforcements, structural steel beams, aggregates, additives, bentonite and water shall be in accordance with the relevant Clauses of Sections 5, 12 and 24 of these Specifications.

All materials must be suitable and fit for purpose, in serviceable condition and acceptable to the Engineer. All component parts of the support and protection system shall comply with the relevant products requirements specified in the related Sections of these Specifications, and in accordance with the latest relevant British Standards or equivalent ASTM.

1. Structural Steel: ASTM A36M
2. Steel Sheet Piling material shall comply with the requirements of ASTM A 328M or ASTM A 572M
3. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of 75 mm.

The Contractor shall submit details for the concrete mix proportions to be used prior to commencing works in compliance with the requirements of Section 5 (Concrete Works) of these Specifications, for the Engineer’s approval.

The Contractor shall submit details for the self-hardening slurry mix proportions to be used prior to commencing works, for the Engineer’s approval.

Trial mixes shall be prepared for each concrete or slurry mix showing their respective mix proportions, method of manufacture, physical & mechanical properties, and especially that they have the adequate workability for compaction by the method to be used in placing. Performance requirements for testing shall be in accordance with the relevant Sections of these Specifications.

Where a support fluid is used for maintaining the stability of the pile bore, the properties and use of the fluid shall be such that the following requirements are achieved:

a. Continuous support of the excavation,
b. The fluid can be easily displaced during concreting,
c. The fluid does not coat the reinforcement to such an extent that the bond between the concrete and reinforcement is impaired,
d. The fluid shall not cause pollution of the ground and groundwater before, during and after use.

Details of the type of support fluid, manufacturer’s instructions and certificates for the constituents and mix proportions, including all additives, shall be submitted by the Contractor to obtain the approval of the Engineer before commencement of the works.

Temporary casings shall be of quality of material, length and thickness adequate for the purpose of preventing unstable soil from entering the pile bore excavations. Temporary casings shall be free from significant distortion.

2601 - EXECUTION

2601.01 PREPARATION

The Contractor shall notify utilities companies and authorities having jurisdiction before commencing special excavation support and protection system operations.

The Contractor shall not interrupt or interfere with utilities serving facilities on the Project site or on adjoining property unless permitted in writing by the Engineer and then only after arranging to provide temporary utility services according to requirements indicated or directed.

The Contractor shall not close or obstruct airfield, roads, sidewalks, pavements, or other adjacent occupied or used facilities without permission from the Employer and authorities having jurisdiction. The Contractor shall provide alternate routes around closed or obstructed traffic ways if required by the authorities having jurisdictions, the Engineer or the governing regulations.

Prior to drilling for tiebacks, investigate to confirm and ensure that installation of anchor tiebacks will not interfere with or cause damage to underground utilities or structures that may exist within immediate vicinity of anchor tieback trajectories.

1. Notify the Engineer and the relevant authorities not less than seventy-two hours in advance of proposed utility interruptions.
2. The Contractor shall not proceed with utility interruptions without the relevant authorities and the Engineer's written permission.
3. Whenever needed, test borings and other exploratory operations shall be conducted, at the Contractor’s own cost and expense.

Before starting work, the Contractor shall check and verify governing dimensions and elevations. Foundation level and type for adjacent structures shall be determined and any prior settlement or cracking of structures or pavements shall be recorded.

The Contractor shall install and construct excavation support and protection systems to ensure minimum interference with adjoining airfield, roads, sidewalks, pavements and other adjacent occupied and used facilities.

The Contractor shall monitor excavation support and protection systems on daily basis during excavation progress and for as long as excavation remains open. The Contractor shall promptly correct bulges, breakage or other evidence of movement to ensure excavation support and protection systems remain stable.

2601.02 CONSTRUCTION

2601.02.1 General

The excavation support and protection system construction shall comply with the construction requirements as follow:

a. install/place the support system,
b. excavate to maximum 0.5 m below the level of anchors,
c. install anchors, tiebacks as required,
d. repeat step b and c as necessary,
e. maintain anchors/tieback until permanent construction is able to withstand lateral earth and hydrostatic pressure.

The Contractor shall drill for, install, tension, and grout tiebacks/anchors into position, test load-carrying capacity of each tieback/anchors and replace and retest deficient tiebacks/anchors.

2601.02.2 Diaphragm Wall

The Contractor shall install slurry diaphragm walls before starting bulk excavation, in panels to the required length, depth and thickness, ensuring vertical alignment and integrity of construction joints. Waterstops shall be installed, where indicated, at construction joints.

The thickness of a panel shall be not less than the specified thickness. The length of panel may be varied to suit the Contractor's equipment subject to any upper limits on length specified (if any). Within these constraints, the Contractor shall be responsible for selecting panel dimensions which ensure stability.

Panels shall not be excavated so close to other panels which have recently been cast and which contain workable or unset concrete that a flow of concrete or instability could be induced or damage caused to any panel. A suitable guide wall shall be used in conjunction with the method to ensure stability of the strata near ground level until concrete has been placed. During construction, and in order to ensure the stability of the excavation trenches, the level of support fluid in the excavation shall be maintained within the guide wall or stable ground so that it is not less than 1.5m above the level of external standing groundwater at all time.

The Contractor shall mix bentonite and any additives thoroughly with clean fresh water in approved proportions to produce a suspension (supporting fluid) which will maintain stability of trench's excavation for period necessary to place concrete and complete construction.

The Contractor shall ensure that the base of the wall is clean from loose material prior to lowering the reinforcement and concreting.

The Contractor shall prepare reinforcement detail construction drawings for each panel and these shall be submitted prior to commencing the works. The number of joints in longitudinal steel bars shall be kept to a minimum. Joints in steel reinforcement shall be such that the full strength of each bar is effective across the joint and shall be made so that there is no detrimental displacement of the reinforcement during the construction of panel. The reinforcement shall be clean and the spacers are in adequate dimensions and manufactured using durable material which shall not lead to corrosion of the reinforcement. Minimum cover to reinforcement is to be not less than 75mm.

The workability and method of placing the concrete shall be such that a continuous monolithic concrete panel of the full cross-section is formed, and that the concrete in its final position is dense and homogeneous. The slump for concrete placed through support fluid using a tremie pipe shall ranges between 150 and 200mm at the time of placing. The Concrete shall be transported from the mixer to the position of the panel in such a manner that segregation of the mix does not occur.

All works shall be in accordance with Sections 5 (Concrete Works) and Section 24 (Piling) of these Specifications.

2601.02.3 Secant and Contiguous Pile Walls

Secant Pile Wall shall be constructed utilizing alternate primary (female) and secondary (male) piles. Primary piles are drilled first, and then concrete is poured. Afterwards, secondary piles are constructed by drilling, overcutting the adjacent primary piles, then reinforcement is installed and concrete is poured. The overlap between piles shall be in the range of 10 to 20% of the pile diameter.

Contiguous Pile Wall shall consist of reinforced piles that are in contact with each other or adjoining. To avoid installation difficulties, the theoretical spacing between contiguous piles shall be in the range of 2 to 5 cm, depending on the soil type.

The Contractor shall be responsible for the accuracy of location and positioning of each pile and wall element including the guide wall. Immediately prior to installation, the pile or wall element positions shall be checked by the Contractor. Any checks by the Engineer shall not relieve the Contractor of his responsibility.

At least one week prior to commencement of the works, the Contractor shall submit to the Engineer a detailed Method Statement describing the construction methodology and equipment to be used for the execution of the secant or contiguous pile walls. Excavation and construction methodology shall results in minimum disturbance of surrounding material and shall be such that a continuous monolithic concrete shaft (pile) and wall element of the specified cross-section is formed to the design level.

Prior to actual pile installation, scalloped guide walls shall be used for all secant pile walls that form part of the permanent works of the structure but may be omitted for temporary works. Similarly, guide walls shall be constructed at platform level for most contiguous bored pile walls. The Contractor shall demonstrate by experience, calculation and monitoring on site that adjacent piles will remain interlocked (for the case of secant piles) or will remain in contact (for the case of contiguous piles) to the entire depth shown on Drawings.

The design and construction of guide walls shall be the responsibility of the Contractor. Guide walls shall be constructed in reinforced concrete or of other suitable materials. The minimum depth of guide wall shall be 0.5 m and the minimum shoulder width shall be 0.3 m for walls in reinforced concrete.

Secant and/or contiguous pile walls shall be constructed by the bored cast-in-situ technique using jointed temporary drill casing or by the Continuous Flight Auger (CFA) technique.

A. Bored Cast-In-Situ Technique:

Piles shall be constructed using suitable and efficient equipment capable of penetrating the ground to the design depth. Where boring takes place through unstable strata, support fluid is used for maintaining the stability of the bore, and a temporary casing shall be used in conjunction with the support fluid so as to ensure stability of the strata near ground level until concrete has been placed.

Secant and/or contiguous piles shall be excavated to dimensions and required elevations shown on Drawings. Sidewall stability shall be maintained during drilling. Piles bores shall be excavated for closely spaced secant or contiguous piles only after adjacent bores are filled with concrete and allowed to set. The primary secant piles will be installed at the spacing shown on Drawings. After a section of primary piles has been installed and the concrete fill allowed to set for a minimum of one (1) day, then the adjacent secondary piles will be installed so that sufficient overlap between the secondary and the primary piles is obtained as shown on Drawings. Concrete in the primary piles should not be allowed to fully set before placing the secondary piles.

Reinforcement element for the secant or contiguous piles shall be structural steel beams and/or rebar cages consisting of longitudinal and spiral bars that are placed vertically in predrilled holes that are alternately backfilled with concrete. Where reinforcement is made up into cages, they shall be sufficiently rigid to enable them to be handled, placed and concreted without damage.

Before placing concrete, the shaft and the bottom of the secant or contiguous piles shall be inspected and cleaned of loose or soft materials. Concrete placement shall proceed immediately after the excavation of pile hole/bore. Concrete placement in each secant or contiguous pile shall be one continuous operation, and without such interruption as would allow the previously placed batch to have achieved a stiffness which prevents proper amalgamation of the two concrete batches. The concrete strength of adjacent primary piles (in the case of secant piles only) should be roughly similar, as it is otherwise difficult to prevent the secondary piles from deviating from their vertical direction.

Concrete shall be placed using hopper and suitable length of rigid delivery tube to direct flow of concrete and ensure that the concrete falls vertically and centrally down the shaft. The method of placing shall be such as to ensure that the concrete in its final position is dense and homogeneous. Two cases are present:

1. Placing concrete in dry borings: Concrete may fall freely, up to a maximum height of 1.8 m provided the concrete does not hit the sides of the secant or contiguous piles and/or the reinforcement. Use tremie pipe if the distance is greater than 1.8 m.
2. Placing concrete under water or support fluid: Concrete to be placed under water or support fluid shall be placed by a full depth tremie pipe in one continuous operation and shall not be discharged freely into the water or support fluid. The tremie pipe shall be fully charged with concrete before it is lifted off the base of the pile bore/hole. The hopper and pipe of the tremie shall be clean and watertight throughout. The tremie pipe shall extend to the base of the bore and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the tremie and the water or support fluid. The pipe shall be at all times penetrate the concrete which has previously been placed with a minimum embedment of 3 m and shall not be completely withdrawn from the concrete until completion of concreting.

When cutting off and breaking down concrete to the specified cut-off levels, the Contractor shall take care to avoid shattering or otherwise damaging the concrete. Any cracked or defective concrete shall be cut away and repaired in a manner to provide a full and sound section at cut-off level.

B. Continuous Flight Auger (CFA) Technique:

The pile shall be constructed in a manner to minimize the occurrence of bulging or heave of the ground such that no detrimental effects occur. If these effects are observed then the fact shall be reported immediately to the Engineer.

The auger shall not be extracted from the ground during the construction of a pile. If during augering, it was necessary to raise the auger and subsequently to re-auger, the required depth shall be increased to at least 0.5m below the depth previously reached (if this is practical), and the fact shall be recorded on the pile record. During concreting, the Contractor shall ensure that the base of the auger is always embedded within fluid concrete. Concrete shall overflow at the ground surface before the auger is removed from the ground.

The reinforcement shall be fabricated as cages, bundles of bars, or structural steel sections fixed securely to permit it to be placed in the correct position and to the depth specified into the fluid pile concrete. All reinforcement shall be placed with the minimum delay after the completion of the concreting operation.

The concrete shall be suitable for pumping. The workability and method of placing shall be such that a continuous monolithic concrete shaft of the specified cross-section is formed. Concrete shall be self-compacted and supplied to the pile through a suitable concrete pump, tubing and the hollow auger stem.

Prior to the commencement of concreting and the removal of augers from the ground, the hollow auger delivery pipe and tubing shall be pre-charged with concrete. For CFA piles, the auger shall be lifted the minimum distance necessary to initiate the flow of concrete, and no more than 100 mm. Concrete shall be supplied to the pile at a sufficient rate during auger withdrawal to ensure that a continuous shaft of at least the specified pile cross-section is formed, free from debris or segregated concrete. The method for the control of concreting that will be used for the construction of the works shall be in accordance with approved Method Statement submitted by the Contractor.

When cutting off and breaking down concrete to specified cut-off levels, the Contractor shall take care to avoid shattering or otherwise damaging the concrete. Any cracked or defective concrete shall be cut away and repaired in a manner to provide a full and sound section at cut-off level.

C. <u>Construction Tolerances on Secant and Contiguous Piles and Guide Walls:</u>

The finished internal face of the guide wall closest to any subsequent main excavation shall be vertical to a tolerance of 1 in 200 and shall represent the reference line. There shall be no ridges on this face and the center line of the guide wall shall not deviate from its specified position by more than ±15 mm in any 3 m along its length. The clear distance between the inside faces of the guide wall shall be the maximum tool diameter plus 25 mm.

The standard installation tolerances for the secant and contiguous pile walls shall be as follows:

Plan position for pile/walls with cut-off level above or at commencing surface	25 mm
Plan position for pile/walls with cut-off level below commencing surface	25 mm + 13.3 mm for every 1 m below cut-off level
Maximum permitted deviation of the finished pile/walls element from vertical at any level	1 in 75 for exposed face

Table 2601.02.1 Secant or Contiguous Pile Installation Tolerances

On completion of the pile, the reinforcement shall be located with vertical tolerance of +150/-50 mm on the level of the reinforcement projecting above the final cut-off level.

The Contractor shall carry out the repair of any joint, defect or pile where on exposure of the secant pile wall, the wall is not deemed “watertight” as stated in the Project Specification.

2601.02.4 Steel Sheet Piles

The Contractor shall install steel sheet piling before starting bulk excavation. The work described under this Clause augments the requirements specified under Section 24 (Piling) of these Specifications.

Only new piles shall be used for permanent works. Piles shall be carefully examined at the time of delivery and damaged piles repaired or replaced. The records of testing of the steel used in the piles shall be submitted prior to commencing the works.

The Contractor shall satisfy himself that the sheet piles can be installed adequately to correct depths through the reported or anticipated soil conditions.

The Contractor shall ensure that the piles to be incorporated into the permanent Works are available at the worksite in time, and the Engineer shall be notified 24 hours before the commencing of driving.

The Contractor shall install one-piece steel sheet piling and tightly interlock to form a continuous barrier. At all stages during driving, the free length of the sheet piles shall be adequately supported and restrained. The Contractor shall ensure that the sheet panels are driven without significant damage.

The selection of driving plant shall be made having due regard to the ground conditions and pile type. The sheet pile shall be driven to the specified level. If the piles have not penetrated to the levels specified and indicated on the Drawings or have encountered obstructions, the Contractor shall submit details as to how he will overcome the problem.

Unless deflected by obstructions, exposed faces shall be accurately aligned of sheet piling to vary not more than 50 mm from a horizontal line and not more than 1:120 out of vertical alignment.

Tops of sheet piling shall be cut to uniform elevation at top of excavation.

Sheet piles shall be provided in one piece unless otherwise specified or approved by the Engineer. In the event, of welding of steel sheet piles, only qualified welders shall be employed on the Works. Defective welds shall be cut out and replaced.

If sheet piles are to be pre-coated, the preparation of surface and application of the coating shall be carried out by experienced specialist labor having experience in the preparation of the surface and the application of coating specified. The finished coating shall be generally smooth, of dense and uniform texture.

2601.02.5 Bracings

If needed; the Contractor shall locate bracing to clear columns, floor framing construction, and other permanent work. If it is necessary to move a brace, the Contractor shall install new bracing before removing original brace.

Bracing shall not be placed where it will be cast into or included in permanent concrete work, unless otherwise approved by the Engineer. Internal bracing, if required, shall be installed to prevent spreading or distortion of braced frames. The bracing shall be maintained until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

2601.02.6 Anchors/Tie-Backs and Grouting

The Contractor shall drill to required length for each anchor tieback. Accurate work records shall be maintained and a log for each drill hole shall be produced in a form acceptable to the Engineer, including the location and identity of drill hole; date and time of starting and completing drilling; overall length of drill hole; description of soil materials recovered; description, location and dimensions of cavities or obstructions encountered; groundwater conditions and unusual conditions encountered and deviations from requirements.

The Contractor shall install, grout into position and tension anchor tiebacks strictly in accordance with the manufacturer's written instructions. The Contractor shall test load-carrying capacity of each anchor tieback in accordance with the requirements of BS EN 1537. The test should be carried to 1.5 times the working load or as indicated on the Drawings. The Contractor shall remove, replace and retest defective or deficient tiebacks, without additional payment or compensation.

2601.03 REMOVAL AND REPAIRS

The Contractor shall, when and where applicable, remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. The support system shall be removed in stages to avoid disturbing underlying soils and damaging structures, pavements, facilities, and utilities.

The Contractor shall repair or replace, as approved by the Engineer, adjacent work damaged or displaced by removing excavation support and protection systems.

Excavation support and protection systems may only be left in place when specifically identified as such on the Design Drawings or when so directed by the Engineer.

The Contractor shall survey adjacent structures and site improvements, employing a qualified professional engineer or surveyor, establishing exact elevations at fixed points to act as benchmarks. Benchmarks and record existing elevations shall be clearly identified.

The Contractor shall monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Weekly, during installation of special excavation and support systems, and at completion, the Contractor shall resurvey benchmarks each week, maintaining an accurate log of surveyed elevations for comparison with original elevations. The Contractor shall promptly notify the Engineer if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

The Contractor shall promptly correct bulges, breakage, or other evidence of movement to ensure excavation support and protection systems remain stable as well as damage to adjacent facilities caused by installing excavation support and protection systems.

2602 - MEASUREMENT AND PAYMENT

2602.01 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

2602.01.1 Steel Sheet Piles

Unless it is deemed to be included in the rates of structural excavation, steel sheet piles shall be measured in square meters of the area of the exposed excavation face. It shall be calculated from data obtained from site measurements or approved shop drawings. No payment will be made for rejected piles, including piles driven out of place, defective piles, or piles damaged during handling or driving.

Payment shall be at the rate included in the Bills of Quantities and the rate shall include for labor, materials, tools, equipment, and incidentals and for performing work for furnishing, driving, and all other ancillaries necessarily required for a complete pile installation. This includes excavation, splicing and disposal of excavated material and cutoffs.

2602.01.2 Diaphragm Wall

Unless it is deemed to be included in the rates of structural excavation, diaphragm wall shall be measured in square meters. The area is calculated by multiplying the nominal length by the depth from the commencing surface.

Payment shall be at the rate included in the Bills of Quantities and the rate shall include for excavation below or above water table; disposal of excavated material; providing and constructing guide walls; backfilling empty trench with excavated material; support fluid including testing and disposal; providing concrete and any method of pouring, placing, compacting and curing, designing mixes; reinforcement content of any percentage of the volume of concrete; day joints (construction joints) including forming stop ends and treatment of reinforcement crossing the joint; water stop joint, preparing cast in pockets or chases including formwork and preparing cast in reinforcement; cutting off walls to specified level including allowance for working tolerances; preparing tops of walls and reinforcement to receive capping, provision and filling of working space and all disposal; trimming and cleaning face of wall; preparing schedules for bar bending.

2602.01.3 Secant and Contiguous Piles

Unless it is deemed to be included in the rates of structural excavation, secant and contiguous piles shall be measured following the same method of measurement and pay items specified under Clause 2405 of Section 24 (Piling) of these Specifications except for the following:

1. Primary and secondary piles shall be measured separately.
2. The rate for guide walls for secant and contiguous pile walls shall be included in the rates for the respective type of piles.
3. The rate for setting up each pile and indicator piles, if any, shall be included in the rates for the respective type of piles.

2602.01.4 Anchors

Unless it is deemed to be included in the rates of structural excavation, anchors shall be measured in meters knowing that each type of temporary anchor is given separately. Lengths are measured along the axes of anchor from commencing surface to bottom of shafts of anchors as shown on the Drawings.

Payment shall be at the rate included in the Bills of Quantities and the rate shall include for mobilization and demobilization; drilling through soil or rock, above or below the ground water level; providing and installing temporary anchor tiebacks, including tendons, spacers, anchor heads, bearings, waler beams and other components; grouting, post-grouting, tensioning and testing, to 1.5 times the working load, or as mentioned on Drawings; removing, replacing and retesting defective or deficient anchor tiebacks; disposal of soil materials arising from drilling operations; method statement, materials, calculations and shop drawings; removing anchors and accessories when and as instructed by the Engineer.

2602.02 ITEMS IN THE BILL OF QUANTITIES

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2602.1	Diaphragm Wall	sq.m
2602.2	Steel Sheet Piles	sq.m
2602.3	Secant Piles (Primary/Secondary/Size/lenght)	m
2602.4	Contiguous Piles (Size/lenght)	m
2602.5	Anchors (type)	m

SECTION 27: PUMPING STATIONS

2700 - GENERAL

2700.01 SCOPE

The works shall consist of the supply and installation of the pumping stations, complete in place, including pipe works, pumps, motors, generators, control center, automatic controls, structural steelwork and miscellaneous supports, connections, valves, appurtenances and all ancillary materials and work items including mechanical, electrical, civil, structural and piping work items needed to complete the work, labor, tests and incidentals, all in accordance with these Specifications, as shown on the Drawings or as ordered by the Engineer.

2700.02 STANDARDS AND CODES

The following standards and codes in their latest editions shall be applied to works covered by this Section, particularly the standards and codes that are directly mentioned in this Section and that are listed below.

BS 822	Terminal markings for electrical machinery and apparatus. Lead colors for rotating electrical machinery.
BS 970	Specification for wrought steels for mechanical and allied engineering purposes.
BS 2613	Electrical performance of rotating machines.
BSI BS ISO 3046	Reciprocating internal combustion engines. Performance
BS 3063	Specification for dimensions of gaskets for pipe flanges.
BS 4147	Steel tubes and fittings for onshore and offshore pipelines. Bitumen hot applied materials for external coating.
BS 4164	Specification for coal-tar-based hot-applied coating materials for protecting iron and steel, including a suitable primer.
BS 4190	ISO metric black hexagon bolts, screws and nuts.
BS 4320	Specification for metal washers for general engineering purposes. Metric series.
BS 4999	General requirements for rotating electrical machines.
BS 5000	Specification for rotating electrical machines of particular types or for particular applications.
BS 5163	Valves for waterworks purposes.
BS 5514	Reciprocating internal combustion engines: performance. Codes for engine power.
BS 6076	Specification for polymeric film for use as a protective sleeving for buried iron pipes and fittings (for site and factory application).
BS EN 124	Gully tops and manhole tops for vehicular and pedestrian areas. Design requirements, type testing, marking, quality control.
BS EN 197	Cement. Composition, specifications and conformity criteria for common cements.
BS EN 286	Simple unfired pressure vessels designed to contain air or nitrogen.
BS EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods.
BS EN 593	Industrial valves. Metallic butterfly valves.
BS EN 681	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications.
BS EN 1092	Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated.
BS EN 1452	Plastics piping systems for water supply. Unplasticized poly(vinyl chloride) (PVC-U). Fittings.
BS EN 1561	Founding. Grey cast irons.
BS EN 1562	Founding. Malleable cast irons.
BS EN 3416	Specification for bitumen-based coatings for cold application, suitable for use in contact with

	potable water.
BS EN 10025	Hot rolled products of structural steels Part 1: General technical delivery conditions
BS EN 10300	Steel tubes and fittings for pipelines. Bitumen hot applied material for external coating
BS EN 12334	Industrial valves. Cast iron check valves.
BS EN 13000	Cranes. Mobile cranes.
ASTM A36	Standard Specification for Carbon Structural Steel.
ASTM A48	Standard Specification for Gray Iron Castings.
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
ASTM A126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
ASTM A157	Specification for Alloy-Steel Castings for Pressure Containing Parts Suitable for High-Temperature Service.
ASTM A216	Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
ASTM B61	Standard Specification for Steam or Valve Bronze Castings.
ASTM B62	Standard Specification for Composition Bronze or Ounce Metal Castings.
DIN 806	Standard Specifications for installations inside buildings conveying water for human consumption.
DIN 8061	Unplasticized polyvinyl chloride (PVC-U, PVC-HI) pipes. General Quality Requirements and testing
DIN 8062	Unplasticized polyvinyl chloride (PVC-U, PVC-HI) pipes; dimensions.
ISO 62	Plastics - Determination of water absorption.
ISO 161	Thermoplastic pipes for the conveyance of fluids
ISO 3067	Short link chain for lifting purposes - Grade T (8), non-calibrated, for chain slings etc.
ISO 8179	Ductile iron pipes - External zinc-based coating.
AISI	American Iron and Steel Institute.
NEMA ICS2	Controllers, Contactors and Overload Relays Rated 600 V.
NEMA 250	Enclosures for Electrical Equipment.
IEC 801	Electromagnetic compatibility for industrial-process measurement and control equipment.
IEC 8528	Reciprocating internal combustion engine driven alternating current generating sets. Test methods.
UL 343	UL Standard for Safety Pumps for Oil-Burning Appliances
UL 508	UL Standard for Safety Industrial Control Equipment.
IEEE 587	Applicability to Adjustable Frequency Control (Surge Voltages).
CSA 282-M-1989	Emergency Electrical Power Supply for Buildings
Mil-Std-461C	Power Leads, Electromagnetic Interference Characteristics, Requirements for Equipment
MSS SP-80	Bronze Gate, globe angle and check valves
AWWA 203	Coal - tar protective coating and lining for steel water pipelines

2701 – MATERIALS

2701.01 METALWORKS – GENERAL

Metalwork includes all purpose-made items shown on the Drawings, materials and workmanship.

Staircases, ladders and safety cages, shall be fabricated from galvanized mild steel or aluminum alloy as approved. Submersed steel structures shall be fabricated from stainless steel.

2701.02 BOLTS, INSERTS AND CUSHIONS

Masonry expansion bolts shall be installed in accordance with manufacturer's instructions.

U-bolts shall be welded to pipes at points of contact and bolted to structural angle frame securely fixed to structure.

Embedded inserts shall be installed during concreting.

Spring cushions shall be used where a horizontal pipe is subject to considerable vertical movement or vibration.

2701.03 COVERS AND FRAMES

Cast iron covers and frames shall be to BS EN 124 Grade B, heavy duty rectangular cover and frame, coated, locking, solid top.

Steel covers and frames: fabricated steel checkered plate, single seal lift out type, hot dipped galvanised, and capable of supporting a load of 5 tones.

2701.04 PAINT AND PAINTING

Paint and painting of all ferrous metal surfaces shall be given one shop coat of rust preventative paint primer and two coats of an approved oil base or alkyd paint as directed by the Engineer.

2701.05 PIPING AND APPURTENANCES

2701.05.1 Special Requirements

Materials shall be supplied with the manufacturer's certificate for each delivery, stating that products comply with and have been factory tested in accordance with specified Standards.

Unless otherwise specified in the relevant Standard, products must have legibly cast, stamped or indelibly painted on, the following marks, as appropriate:

- Manufacturer's name, initials and identification mark.
- Nominal diameter.
- Class designation.
- Initials and number of relevant Standard.
- Length of pipe if shorter than standard length.
- Angle of bends in degrees.
- Date of manufacture.

Whenever required by the Engineer, the Contractor shall arrange to collect samples of the materials selected by the Engineer, and shall arrange to transport them and have them tested by an independent Laboratory. The Contractor shall bare all the expenses in this respect.

2701.05.2 Pipes and Fittings

Ductile iron pressure pipe: pipes used for water systems shall conform to BS EN 545, Class K9.

- Fittings shall conform to BS EN 545, pressure rating suitable to sustain the system working pressure.
- Flanged pipes shall have screwed-on or cast-on flanges to sustain the system working pressure.
- Flanges shall conform to BS EN 1092 with pressure rating suitable for the system working pressure.

Factory protection for water supply fittings:

- Coated internally and externally by dipping, or other method, using hot applied coal tar based material to BS 4164 or hot applied bitumen based material to BS EN 10300.

Factory protection for water pipes:

- Pipes shall be internally cement lined to BS EN 545 with ordinary Portland cement to BS EN 197-1 to specified thicknesses.

- Externally, pipe shall be coated with metallic zinc to BS EN 545 and followed by a bitumen coat to BS 3416 of minimum thickness 6 mils. A hot applied coal tar based material to BS 4164 may replace the bitumen coat.

uPVC pressure pipe: pipe shall conform to BS EN 1452, DIN 8061/8062 series 4 and 5 or ISO 161 class 10 or 16.

Fittings shall conform to BS EN 1452, injection molded type joints shall be solvent welded to BS EN 1452 Part 1.

2701.05.3 Pipe Accessories

Ferrous flexible pipe couplings: types shall be straight couplings to bridge two plain ended pipes of same outside diameter and stepped couplings for pipes of large diametrical differences. Couplings shall be with center register.

Material shall be malleable iron conforming to BS EN 1562 grade 20/10 or rolled steel to BS 970- 060A12 with bolts to BS 970-EN3A and rubber rings to BS EN 681.

Couplings shall be able to take 6 deg. angular deflections for sizes up to 600 mm diameter reducing to 2 deg. for sizes up to 1800 mm diameter.

Couplings shall be factory coated with cold applied bitumen or hot applied coal tar conforming to BS EN 3416 or BS 4164 respectively, thickness 1 mil.

Ferrous flanged adaptors: material shall be cast iron body conforming to BS EN 1561 grade 14 or mild steel plate to BS 10025 and malleable cast iron flange to BS EN 1562 grade 20/10 or rolled steel to BS 970-EN3A and rubber rings to BS EN 681.

Length of adaptor shall be 200 mm for diameters up to 150 mm, 250 mm for diameters between 200 and 300 mm and as approved by Engineer for diameters larger than 300 mm.

Adaptors shall be factory coated with cold applied bitumen or hot applied coal tar conforming to BS EN 3416 or BS 4164 respectively.

Flexible pipe connections: flexible connections shall be seamless bronze tubing with annular corrugations covered with high tensile bronze braid suitable for the system working pressure.

Connections shall have screwed ends for pipes 50 mm diameter and under and flanged ends for pipes over 50 mm diameter.

Flexible couplings: gasket sleeve type, shall allow angular deflection and axial movement of two joined pipe ends and to maintain permanent, leak-tight joint.

Components shall comprise one center sleeve, two end followers or flanges, two rubber-compounded wedge-section gaskets and sufficient draw bolts and nuts to properly compress gaskets. Tightening of bolts to draw end followers together must compress gaskets in recess between center sleeve and followers onto pipe ends to affect positive seal.

Couplings shall have diameter specifically supplied for and to properly fit type of joined pipe ends. Center sleeve shall be of adequate thickness and whole coupling suitable for minimum working pressures shown on the Drawings.

Center sleeve and followers shall be true circular sections, free from irregularities, flat spots or surface defects and formed from steel mill sections with space between sleeve and follower designed to provide confinement of gasket.

Bolts shall be special steel having minimum yield strength of 2800 kg/cm2 and ultimate strength of 4200 kg/cm2. Bolts shall be track-head design to prevent turning when nut is drawn up and threads shall be rolled with a nominal diameter larger than diameter of shank. Manufacturer must supply information regarding recommended torque to which bolts must be tightened.

Gaskets shall be synthetic rubber-base compound with other products to produce material which will not deteriorate from age, heat or exposure to air and which is resilient and able to resist cold flows so that the joint will remain sealed and tight indefinitely when subjected to shock, vibration, pulsation, temperature and adjustment of connected pipes.

Coupling shall be factory painted internally with 200 microns coating of epoxy and externally with red primer conforming to AWWA 203 Type B chlorinated rubber solution compatible with bitumen, coat tar and general paints.

Couplings shall be assembled on site in accordance with manufacturer's instructions to ensure permanently tight joints under all conditions of expansion, contraction, shifting and settlement.

Dismantling couplings shall have an extensible connection between pipe sections, and be mounted next to valves to enable easy dismantling from pipe work or to permit pipe joining when butterfly valve is removed for maintenance.

Dismantling piece shall be flanged type composed of two parts, one sliding into the other, and a free flange to compress a trapezoidal section seal to ensure water tightness. Coupling shall have locking devices to provide elements of complete rigidity.

Construction shall be all steel with flanges having rating matching adjoining pipes.

Couplings shall have diameter specifically supplied for and to properly fit type of joined ends of pipes and valves. Coupling shall permit tightening of end flanges without risk of misalignment. Seal shall be locked after end joints are tightened.

2701.05.4 Jointing Material

Gaskets shall be elastomeric full face 3 mm thick joint rings conforming to BS EN 681 with dimensions conforming to BS 3063.

Rings shall be elastomeric conforming to BS EN 681. Dimensions to manufacturer's recommendations to suit type of joint required.

Bolts and nuts shall be ISO metric black hexagon conforming to BS 4190, minimum tensile strength 433 MN/m2, maximum elongation 27%. After fixing, bolt projection shall be maximum 6 mm, minimum 3 mm.

Washers shall be black steel conforming to BS 4320.

Dielectric Joints shall have insulating neoprene or phenol gasket between flanges and phenol or polyethylene sleeves and washers between bolts, nuts and flanges. Joints shall be suitable for the operating pressure of the system.

2701.06 VALVES AND ACCESSORIES

2701.06.1 Gate Valves

Cast iron gate valves: type shall conform to BS 5163, inside screw, solid wedge, resilient seated, bolted bonnet, non-rising stem type, suitable for the system working pressure.

Material of component parts shall be from basic or alternative materials listed in BS 5163.

End connections shall be as shown on the Drawings. Flanged end connections shall conform to BS EN 1092. Plain end connections shall be machined to suit joints specified for adjoining pipes.

Casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar or cold applied bitumen conforming to BS 4164 or BS EN 3416 respectively. Thickness of coat shall be 10 mils.

2701.06.2 Butterfly Valves

Cast iron butterfly valves: type shall conform to BS EN 593 with resilient seating suitable for system working pressure. Component parts shall be from basic materials listed in BS EN 593 Table 3.

For valves 100 mm and smaller, operation shall be by lever arm. For sizes above 100 mm and up to 250 mm, operation shall be by hand wheel. For valves 300 mm and larger shall be gear operated.

Casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar or cold applied bitumen conforming to BS 4164 or BS EN 3416 respectively. Thickness of coat shall be 250 microns.

2701.06.3 Check Valves

Cushioned check valves: type shall be cushioned type, counter-weighted metal seated check with attached cushion chamber to permit valve to close without slam or bang. Valve shall have a pressure rating suitable for the system working pressure.

Cast iron body shall conform to ASTM 126 Class B or cast steel body to ASTM 216 Class WCB depending upon working pressure and with stainless steel seat ring to ASTM A157 C9 non-corrosion shaft for attachment of weight and lever and complete non-corrosion shock less chamber to ASTM B 62. Valve shall be tight seating and seat ring shall be removable. Cushion chamber shall be attached to side of valve body and constructed with a piston operating in a chamber to permit valve to operate without hammering action. Shock absorption shall be by dry air and cushion chamber shall be arranged for closing speed to be adjustable to meet service requirements. Valve disc shall be of same material as valve body and shall be suspended from a stainless steel type 303 shaft connected to the cushion chamber through a stuffing box.

End connections shall be as shown on the Drawings. Flanged end connections shall conform to BS EN 1092.

Valves shall be factory protected with an internal coating of epoxy to a thickness of 120 microns and external coating of epoxy and nickel plating to a thickness of 120 microns.

Cast iron check valves: type shall conform to BS EN 12334, swing straight pattern, for vertical use and with pressure rating suitable for the system working pressure.

Material of component parts shall be from basic materials listed in BS EN 12334 table 5, under 'copper alloy faced'.

Seating or facing rings shall be renewable. An arrow showing direction of flow shall be visible from outside and cast integral with the valve housing.

End connections shall be as shown on the Drawings. Flanged end connections shall be to BS EN 1092.

Casting surfaces shall be given at factory an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar or cold applied bitumen to BS 4164 or BS EN 3416 respectively. Thickness of coat shall be 10 mils.

Silent check valves: type shall be non-slam, spring loaded and suitable for installation in any position.

Valves 50 mm diameter and under shall be screwed, with bronze body, seat and disc, 18-8 stainless steel spring, with pressure rating suitable for the system working pressure.

Valves over 50 mm diameter shall be flanged, with cast iron body, bronze seat and disc, 18-8 stainless steel spring, with pressure rating suitable for the system working pressure.

Valves shall have straight guided disc with two-point bearing. Wearing parts including discs, seats and other guide bushings shall be replaceable.

Valves shall have flow area in excess of pipe area for minimum pressure drop.

2701.06.4 Control Valves

General: pump control valves, and surge control valves, shall be automatic, hydraulically operated, pilot controlled, piston actuated, single seated, globe or angle pattern as shown on the Drawings, consisting of valve body, piston assembly and cover with the piston assembly as the only moving part. Valves shall be sized for pressure rating shown on the Drawings and shall be the product of a reputable, approved manufacturer.

Valve body shall be cast steel to ASTM A216 WCB standard, flanged, with flange rating as shown on the Drawings and containing a removable seat insert. Main valve trim shall be bronze to ASTM B 61.

Piston assembly shall be fully guided on its outside diameter by long stroke stationary V-ports downstream of seating surface to minimize consequence of throttling. Piston shall be bronze to ASTM B 62 with seal of stainless steel to AISI 140.

Repairs shall be possible without removing valve from line. Valve shall have no external packing glands or stuffing boxes.

Valve shall be supplied complete with factory fitted pilot valves, small interconnecting piping and accessories to perform required functions. Pilot control system shall be stainless steel to AISI type 303.

Factory protection shall be internal coating of epoxy to a thickness of 120 microns and external coating of epoxy and nickel plating to a thickness of 120 microns.

Provide manufacturer with necessary and pertinent data for setting control valves, at factory, to required settings to suit individual conditions of different pumping stations.

Prior to shipping valves from factory, submit shop drawings for approval giving factory settings, range of adjustments, control diagram, wiring diagram, size, arrangement and other pertinent data necessary for approval by the Engineer of every control valve in the system. Submit with the shop drawings detailed instructions for field adjustment and setting, installation, start-up and proper operation. All submittals shall be in the English language.

Each control valve shall be tested individually at factory and certified test results submitted.

Provide the services of a specialized factory technician or engineer to set, test, adjust and commission the control valves as specified.

Control valve pressure rating shall be suitable to system working pressure.

Surge control valves: type shall be straight pattern, specifically designed to prevent excessive surge pressures in event of power failure. Valve shall have pilots to cause valve to open on either low pressure or high pressure wave. Under normal operation, valve acts as relief valve which can be set to open at any pressure above normal operating pressure. At the same time, valve shall open at any set pressure below its normal operating pressure.

Function shall be such that on power failure, valve opens on initial down-surge in pressure (if this surge is not already controlled by surge chamber) and remains open until high pressure wave returns and passes through valve without generating a large up-surge in pressure. After high pressure wave has passed, valve closes slowly

in 2 minutes to prevent further pressure surges. Valve also opens on high pressure unless surge has been attenuated by surge chambers.

Operation shall be on differential piston principle such that area on underside of piston is no less than pipe area, and area on upper surface of piston is of greater area. Valve shall operate in any position without assistance of springs.

Valve size shall be as shown on the Drawings and pressure rating shall be suitable for system operating and anticipated maximum surge pressure. Valve shall be of extra heavy construction throughout with body of cast steel to ASTM A216 WCB and flanges conforming to ANSI standards. Internal trim shall be bronze to ASTM B 62. Piston shall be guided on its outside diameter by long-stroke stationary V-ports downstream of seating surface to minimize consequence of throttling. Piston shall be bronze and pilots stainless steel. Valve shall contain rubber removable seat insert.

Repairs shall be possible without removing valve from line. Valve shall have no external packing glands or stuffing boxes.

Pilots and accessories shall include the following:

- Low pressure pilot.
- Pressure relief pilot.
- Flow limiting device.
- Needle valves.
- Strainer.
- Check valve.
- Valve position indicator.
- Pipe plug for pressure gauge.
- Shut-off cocks.
- Interconnecting copper tubing and unions.
- Pilot mounting bracket.
- Other accessories recommended by manufacturer.

Factory protection shall be complete epoxy coating for protection against corrosion.

2701.06.5 Sundries

Hose Bibb: to consist of chrome plated metal bibcock, 15 mm male back inlet connection and 15 mm male, hose thread outlet, with 15 mm chrome plated metal hose coupling female threaded.

2701.07 MEASUREMENT AND PAYMENT

2701.07.1 Method of Measurement and Basis of Payment

Metalwork including but not limited to staircases, ladders, and safety cages; bolts, inserts and cushions; covers and frames; shall be measured by an item furnished, installed, tested and accepted, inclusive of preparing, priming and painting.

Pipes shall be measured by linear meter of each type and size of pipe. Measurement shall be of the center line of pipes (overall), couplings, fittings and branches. Pipes shall be deemed to include all related pipe work, including but not necessary limited to:

- Flexible pipe couplings adaptors and connections.
- Header pipes and dismantling couplings.
- Purpose made pipes and purpose made fittings.
- Everything necessary for jointing.
- Bends, tees, joints, unions, flanges, and pipe fittings including cutting and jointing pipe to fittings, valves and equipment.
- Pipe supports and support assemblies, hangers, clips, anchors and guides.

- Wrapping and waterproofing of underground and or exposed pipes.
- Pipe sleeves and packing.
- Pipe cleaning priming and painting.
- All other pipe and pipe work ancillaries' necessary required or reasonably inferred.

Valves shall be measured by the number of each type furnished, installed, test and accepted.

2701.07.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2701.1	Metal works	item
2701.2	Ductile Iron pressure pipe (state size)	m
2701.3	uPVC pressure pipe (state size)	m
2701.4	Gate Valves (state size)	nr
2701.5	Butterfly Valves (state size)	nr
2701.6	Check Valves (state size)	nr
2701.7	Silent Type Check Valves (state size)	nr
2701.8	Control Valves (state size)	nr
2701.9	Surge Control Valves (state size)	nr
2701.10	Cushioned Type Check Valves (state size)	nr

2702 - EQUIPMENT

2702.01 GENERAL REQUIREMENTS

Materials and products: materials for pumps shall be suitable for pump operating conditions and adequate for total heads to which pumps are subjected. Corrosion resistant materials shall be used. Assembly arrangements shall include isolation of dissimilar metals to avoid galvanic interaction.

Pumps shall have factory plugged connections for casing vent, drain and suction and discharge pressure gauges.

Impellers and rotating assemblies shall be statically and dynamically balanced at factory.

Packing rings shall be installed in alternate layers staggered 90 degrees. Packing shall be tightened for seal while permitting prescribed amount of leakage for lubrication.

Pumps shall have shaft packing or mechanical seals compatible with pump design and nature of liquid pumped in accordance with manufacturer's recommendations or as specified.

Pump operating point of specified flow and head shall fall near the point of maximum efficiency as obtained from manufacturer's published data.

Horsepower rating of pump drive motor shall ensure non-overloading of motor throughout capacity range of pump for impeller diameter selected.

Electric motors shall be suitable for available electric current voltage and frequency. Motor speeds shall not exceed 1450 rpm for 50 Hz. Motors shall be designed to operate in 50^{o}C ambient temperature.

Shop drawings: The Contractor shall submit shop drawings for each pump for approval, prior to shipment from factory, as follows:

- Certified performance curves showing job number, customer and customer order number, pump designation number shown on the drawings, date of manufacture, model number, pump size, impeller diameter, impeller type, maximum impeller diameter pump can accommodate, rpm, noise data, flow-head characteristic curve, consumed horsepower curve and pump efficiency curve.
- Pump cross-sectional drawings showing major components with parts numbers and parts list.

- Pump outline dimensional drawing showing overall dimensions, location of foundation bolt holes and sizes, location and rating of suction and discharge nozzles.
- Recommended list of spare parts, where not specified elsewhere.
- Installation, operation and maintenance instruction manual.
- Details and wiring diagrams of factory supplied pump controllers, starters, controls or other electrical device or accessory.
- Special instructions for field installation and connection of factory or field supplied electrical device, control or accessory.

Shop tests: The Contractor shall submit for each pump, certified results of shop tests made by manufacturer, prior to shipment from factory, as follows:

- Performance test throughout capacity range of pump with specified design operating point clearly indicated on pump flow-head characteristic curve.
- Hydrostatic pressure test to 1-1/2 times shut-off pressure of pump.
- Pump test report shall include the following information:
- Pump data: pump designation number shown on the Drawings, model number, serial number, customer order number, flow, suction and discharge pressures, shut-off pressure, rpm and brake horsepower.
- Motor data: make, model number, serial number, horsepower rating, rpm, voltage, phase, frequency, class of insulation, allowable temperature rise, full load amperes, locked rotor amperes and actual voltage and amperes at all test points.
- Starter data: make, model number, size, heater sizes, ampere rating, line voltage, control voltage and frequency.

All submittals shall be in the English language.

2702.02 PUMPS

2702.02.1 Submersible Drainage Pump

Non-clog, centrifugal, submersible, with guide-rails, quick-disconnect type, suitable for drainage water application and designed to permit quick and easy ground level removal of pump from pit for service or inspection without disconnecting or disturbing discharge piping and electrical connection. Pump design shall permit pump to be automatically connected to discharge elbow in a tight and leak-proof manner without axial or lateral movement and without further adjustment. Pump shall be designed to withstand dry running.

Each pump shall be supplied complete with the following:

- Close-coupled submersible vertical electric motor.
- Required length of durable multi-conductor waterproof electric cable.
- Special quick disconnect flange elbow with integral bracket for floor mounting and lower guide rail holder.
- Required length of stainless steel guide rails.
- Upper guide rail bracket.
- Rail guided lifting assembly.
- Lifting yoke and stainless steel chain for raising and lowering pump.

Casing shall be cast iron volute, to ASTM A48 Class 35B or BS EN 1561 Grade 260, horizontally split. Passageways shall permit smooth flow of liquid served and shall be free from sharp turns and projections. Pump volute bottom and impeller shall have easily replaceable stainless steel wear rings.

Impeller shall be cast iron to ASTM A48 Class 35B or BS EN 1561 Grade 260, single channel type running in volute, capable of passing solids with 75mm diameter, suitable for service required, non-clog and dynamically balanced for smooth operation. Impeller parts and internal parts including studs, nuts and screws shall be stainless steel.

Mechanical Seal System shall consist of two independent seal assemblies and of materials suitable for the application.

Motor shall have Class F insulation, designed for use in hazardous locations, suitable for continuous duty, with horsepower to ensure non-overloading of motor throughout capacity range of pump. Motor shall have cast iron frame, stainless steel shaft, double mechanical shaft face seals of carbon/tungsten carbide, built-in thermal overload protection and moisture sensing probes. Motors shall be dimensioned to be sufficiently cooled by surrounding environment or pumped media.

Pump and motor bearings shall be heavy-duty, permanently lubricated and sealed ball bearing type, not requiring re-lubrication on site.

Pump shall be supplied from factory with required number of level regulators of the pear-shaped type, with internal coated type switch and weighted to be vertical in air and horizontal in water without floating. Regulator shall have three contacts to make it suitable for either starting or stopping motors. Regulators shall have necessary lengths of three-core electric cable and both regulator case and cable insulation shall be non-corrosive material resistant to and for application in liquid served. Level regulators shall be supplied from factory with special cable holder bracket designed to guide and support power and level regulator cable. Level regulators shall start and stop pumps at pre-set levels through the control panel. Levels shall be shown on the Drawings. In the event of a fault in one pump, control panel shall switch off defective pump give an alarm signal and start stand by pump. Starting sequence of pumps shall be automatically alternated through the control panel.

Pump motor control panel shall be weatherproof and suitable for outdoor installation, minimum IP 55 enclosure protection, with lockable cover and completely assembled, wired and tested at factory ready for installation with simple external electrical connections. Panel shall contain, but is not necessary limited to, the following:

- Motor starters.
- Over-Riding starter buttons.
- Indicating lamps for pump in operation.
- Reset buttons for overload relays.
- Electric alternator for required number of pumps.
- 24 V control circuit transformer.
- Running hour meters to record time each pump is in operation.
- Accessories required for automatic operation of pumps.
- Auxiliary volt free contacts for remote monitoring and alarms.
- Water level meter for water level in well.

Impeller and pump outer casing shall be factory protected by shot blasting and priming with epoxy suitable for duty. Casing shall then be given two coats of epoxy resin, to 125 microns thickness each coat.

2702.02.2 Horizontal Pumps

Description: Horizontal, base-mounted, centrifugal, flexible-coupled, rated for minimum 1.5 times the working pressure.

Pumps shall be end suction, horizontal multi-stage, or split case pumps, type as required by the design Drawings.

End suction pumps: shall be back-pull-out, radial split case design.

Split case pumps: shall be with axially split casing design.

Construction Features

1. Casing: Cast iron, with integral feet or other means on volute to support weight of casing and attached piping.
2. Impeller: ASTM A48 Class No 25 A or higher cast iron, statically and dynamically balanced, closed, single suction, keyed to shaft, and secured by locking cap screw.
3. Wear Rings: Replaceable type with material suitable for the application.
4. Shaft and Sleeve: High grade Stainless-steel shaft and rated for minimum 1.5 times the working pressure, and high-grade stainless steel sleeve.

5. Seals: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.
6. Coupling: Flexible-spacer type, capable of absorbing torsion vibration and shaft misalignment; with flange and sleeve section that can be disassembled and removed without removing pump or motor.
7. Coupling Guard: Galvanized steel, removable, and attached to mounting frame.
8. Mounting Frame: Factory coated welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Field-drill motor-mounting holes for field-installed motors.

Motor: Secured to mounting frame, with adjustable alignment. Motors: IP 55, squirrel cage induction type, and fan cooled. Cooling fans shall be bi-directional so that cooling is independent of direction of rotation and shall be fabricated from non-rusting and non-sparking material.

Motors shall have high efficiency and high power factor at full load. All motors shall meet or exceed the minimum efficiencies stated in the highest level in the EU agreement of the LV motors (EFF1/EFF2). All motors shall bear the IEC reference and CE marking on the motor nameplate.

All motors shall be suitable for continuous heavy-duty application with a minimum service factor of 1.25; alternatively, the next larger IEC motor size shall be selected.

Motors shall be full voltage direct-on-line start.

Motor Insulation shall be class F, non-hygroscopic, class H varnish.

Motor Temperature rise shall be limited to 70°C above the maximum ambient temperature of 50°C, as measured by resistance.

2702.02.3 High Pressure Booster Pumping Set Employing Membrane Tank

Packaged type, comprising multiple close-coupled pumps, membrane tank, interconnecting pipe work, valves, pressure switches and electrical control panel all completely assembled on steel frame, piped, wired and delivered as a complete packaged unit ready for installation and operation with simple piping and electrical connections. One of the pumps shall be stand-by pump.

Pumps shall be close-coupled, centrifugal, of single or multiple stage type, horizontally or vertically mounted and driven by electric motor at specified rpm. Pumps shall have self-adjusting mechanical seals with carbon rotating face running against stationary ceramic seat. Pumps shall have close-grain cast iron or stainless steel casing and mechanical seal housing, gunmetal, cast bronze, or stainless steel impeller and stainless steel shaft.

When the duty pumps shall be running together, they shall supply the maximum demand specified with the remaining pump acting as stand-by. Under low demand conditions one pump shall supply sufficient water with remaining duty pumps acting as back up. Controls shall automatically start second duty pump when one pump is unable to supply demand and to cut in stand-by pump on failure of any of the duty pumps.

Motor shall be totally enclosed, fan cooled, drip proof, squirrel cage type, weatherproofed construction for operation in specified ambient temperatures. Motor horsepower shall ensure non-overloading of motor throughout capacity range of pump.

Membrane tank shall be welded mild steel plate, suitable for system operating pressure constructed in accordance with BS EN 286-1, Part 1, with cylindrical shell and convex dished ends. Membrane tank shall contain removable rubber bag and shall be pressurized with air at factory to correct system operating pressure to provide sealed air cushion eliminating use of air compressor. Tank shall have air valve of type permitting recharging on site by small hand compressor or simple car type pump. Rubber bag shall be guaranteed suitable for intended use without deterioration and without bursting.

Membrane tank shall be complete with factory fabricated steel legs welded to tank before testing, air-charges connection, pressure relief valve and pressure gauges.

Pumping set shall be automatically controlled by pressure switches to start pumps on fall of pressure in tank and stop pumps on rise of pressure.

Interconnecting pipe work shall be galvanized steel pipe and fitting to ASTM A53 schedule 40. Valves shall be threaded, with bronze body and trim and having a pressure rating suitable for system working pressure. Each pump shall have-swing type, non-return valve at discharge adjustable, pilot-operated pressure regulating value at discharge, adjustable, individual suction and discharge shut off valves, Discharge manifold shall have pressure switches, pressure gauge and vent cock.

Control panel: shall be heavy gauge mild steel sheet finished with stove hammer paint internally and externally with minimum IP 55 enclosure rating. Control panel shall be automatic, with load control and protection function and shall contain, but shall not be necessarily limited to, the following:

- Mounting and Wiring: Factory installed and connected as an integral part of unit.
- Enclosure: IP 55.
- Motor Controller: Full-voltage, combination-magnetic type with under-voltage release feature, motor-circuit-protector-type, and short-circuit protective device.
- Motor Overload Protection: Overload relay in each phase.
- Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
- Multi-pump, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to multi-pump operation.
- Instrumentation: Unit suction and discharge pressure gauges.
- Alarm Signal Device : Sounds alarm when backup pumps are operation.
- Pump Duty Alternation Device: Switches the lead pump.

Mounting frame shall be mild steel hollow section members reinforced against deflection and with bolt holes. Steel surfaces shall be factory protected by shot blasting, zinc sprayed to 75 microns thickness and given one coat of priming paint. External steelwork shall have one undercoat and one top coat chlorinated rubber of approved color to 75 microns thickness each coat. Internal steelwork shall have two coats black bitumastic paint, 125 microns thickness each coat and suitable for service.

2702.02.4 High Pressure Booster Pumping Set Employing Variable Speed Pumps

Packaged type, comprising multiple close-coupled pumps, membrane tank, interconnecting pipe work, valves, pressure switches and electrical control panel all completely assembled on steel frame, piped, wired and delivered as a complete packaged unit ready for installation and operation with simple piping and electrical connections. One of the pumps shall be stand-by pump

Pumps shall be close-coupled, centrifugal, of single or multiple stage type, horizontally or vertically mounted and driven by electric motor at specified rpm. Pumps shall have self-adjusting mechanical seals with carbon rotating face running against stationary ceramic seat. Pumps shall have close-grain cast iron or stainless steel casing and mechanical seal housing, gunmetal, cast bronze, or stainless steel impeller and stainless steel shaft.

When the duty pumps shall be running together, they shall supply the maximum demand specified with the remaining pump acting as stand-by. Under low demand conditions one pump shall supply sufficient water with remaining duty pumps acting as back up. Controls shall automatically start second duty pump when one pump is unable to supply demand and to cut in stand-by pump on failure of any of the duty pumps.

Motors: Variable speed, with pre-greased, permanently shielded, ball-type bearings. Select motors that will not overload through full range of pump performance curve.

Membrane tank shall be welded mild steel plate, suitable for system operating pressure constructed in accordance with BS EN 286-1, Part 1, with cylindrical shell and convex dished ends. Membrane tank shall contain removable rubber bag and shall be pressurized with air at factory to correct system operating pressure to provide sealed air cushion eliminating use of air compressor. Tank shall have air valve of type permitting recharging on site by small hand compressor or simple car type pump. Rubber bag shall be guaranteed suitable for intended use without deterioration and without bursting.

Membrane tank shall be complete with factory fabricated steel legs welded to tank before testing, air-charges connection, pressure relief valve and pressure gauges.

Pumping set shall be automatically controlled by pressure switches to start pumps on fall of pressure in tank and stop pumps on rise of pressure.

Interconnecting pipe work shall be galvanized steel pipe and fitting to ASTM A53 schedule 40. Valves shall be threaded, with bronze body and trim and having a pressure rating suitable for system working pressure. Each pump shall have-swing type, non-return valve at discharge adjustable, pilot-operated pressure regulating value at discharge, adjustable, individual suction and discharge shut off valves, Discharge manifold shall have pressure switches, pressure gauge and vent cock.

Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, variable-speed operation, with load control and protection functions, and shal contain, but not necessarily be limited to the following:

1. Control Logic: Solid-state system with transducers, programmable microprocessor, VFC, and other devices in controller. Install VFC for pump motors larger than 25 Hp in separate panel; same type as motor control panel enclosure.
2. Motor Controller: NEMA ICS 2, variable-frequency, solid-state type. Some manufacturers may offer low-voltage controls. Revise "Control Voltage" Subparagraph below if required.
   - Control Voltage: 220 V AC, with integral control-power transformer.
3. Enclosure: NEMA 250.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control. Retain one of first two subparagraphs below.
   - For duplex boosters, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.
   - TFor triplex or multiplex boosters, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to three-pump operation.
6. Pump Operation and Sequencing: Pressure-sensing method.
   - Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
7. VFC: Voltage-source, pulse-width, modulating-frequency converter for each pump.
8. Manual Bypass: Magnetic contactor arranged to transfer to constant-speed operation upon VFC failure.
9. Instrumentation: Suction and discharge pressure gages.
10. Lights: Running light for each pump.
11. Alarm Signal Device: Sounds alarm when backup pumps are operating.
    - Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with manual reset.
12. Thermal-bleed cutoff.
13. Low-suction-pressure, Water-storage-tank, low-level cutout.
14. High-suction-pressure cutout.
15. Low-discharge-pressure cutout.
16. High-discharge-pressure cutout.

2702.02.5 Duplex Sump Pumps

Components shall comprise two pumps, float switch assembly with mechanical alternator, high water alarm and electric control panel.

Pump shall be vertical, centrifugal, wet pit type, self lubricating, to rest directly on sump floor, with vertical motor connected to pump with steel tubular shaft housing.

Pump shall be supplied complete with the following, factory assembled to form a self-contained, compact unit ready for operation with simple discharge piping and electrical connections:

- Cast iron combination base and suction strainer.
- Cast iron motor head box.
- Cast iron motor adaptor flange designed to carry motor and float switch.
- Steel tubular shaft housing.

- Electric motor.
- Unsinkable plastic float and stainless steel rod.
- Adjustable stops and counter-weight.

Casing and cover shall be close grained cast iron volute of uniform quality, free from blow-holes, porosity shrinkage defects, cracks and other defects.

Impeller shall be cast iron volute to ASTM A 48 Class 35B or BS EN 1561 grade 260, heavy open non-clog type design, statically and dynamically balanced, over hung, single suction, keyed and securely locked to stainless steel shaft of size to transmit required power without distortion or vibration. Pump shaft shall be directly connected to motor shaft through a flexible coupling. Motor adaptor flange shall be machined to close tolerances to ensure permanent alignment between pump and motor.

Pump shall be fitted at drive end of shaft with grease packed, deep groove, self-aligning, radial thrust ball bearing, mounted in dust-proof housing machined in motor support base and having moisture proof seal protection from sump vapors. Pump shall also have bottom column bearing of renewable water-lubricated type.

Motor shall be vertical, totally enclosed, squirrel cage, induction type, permanently lubricated with sealed ball bearings. Motor horsepower shall ensure non-overloading of motor throughout capacity range of pump. Motor shall be suitable for continuous operation in ambient temperature specified.

Operation shall be automatic, float switch operated, alternating start-up sequence. One pump shall be intended for normal operation, while the other for backup. Standby pump to start if abnormal flow exceeds one pump capacity and in the event of a fault in other pump. Fault condition in a pump or if flow exceeds pumping capacity shall actuate an alarm.

Float switches shall be base mounted, contact type, enclosed in drip-proof and splash-proof enclosure.

Starters shall be totally enclosed, wall mounted, direct on-line type with no-volt and overload protection and suitable for automatic operation.

Control panel shall be wall mounted, watertight, completely assembled, wired and tested at the factory and ready for installation with simple connections.

Control panel shall have minimum IP 55 enclosure.

Control panel shall contain all necessary accessories for duplex pump operation, including, but not necessarily limited to the following:

- Main incoming isolating switch.
- Magnetic trip circuit-breakers.
- Magnetic starters.
- Overload relays with thermal unit
- HAND-OFF-AUTO selector switches.
- Electric alternator between duty and stand-by.
- High and low level alarms.
- 24 V control circuit transformer.
- Manual reset fail-safe alarm circuits.
- Pilot lights.
- Moisture sensing relay.
- Loss of power alarm unit.
- Auxiliary, volt free, contracts for remote monitoring and alarms.

Cables, wiring and conduits shall be provided as necessary for connecting control panel to pumps, float switch assembly and alarm unit. Make connection as per manufacturer's wiring diagram.

Impeller and pump outer casing shall be factory protected by shot blasting and priming with suitable epoxy. Casing shall then be given two coats of epoxy resin, to 125 microns thickness each coat.

2702.03 SURGE TANKS

Membrane tank is to contain interchangeable bladder and be pre-charged with air at factory to correct pressure to provide sealed air cushion eliminating use of an air compressor. Tank shall have air valve to permit recharging on site by small compressor. Bladder to be guaranteed by manufacturer for use on pumped fluid without deterioration with time and without bursting. Tank to be welded mild steel plate for operating pressure of 16, 25, and 40 bars (as shown on Drawings), with cylindrical shell and convex dished ends, shot blasted and painted internally with bitumastic paint and externally with zinc primer and hammer enamel paint.

The tank shall be horizontally installed and shall be supplied from factory complete with the following accessories:

1. Access manholes.
2. Hoisting hooks.
3. Inflator valve.
4. Flange and counter flange for fixing of the bladder.
5. Flanged water connection.
6. Pressure gauge.
7. Level gauge system.

2702.04 OVERHEAD MATERIAL HANDLING EQUIPMENT

Monorail System

System shall comprise of a carrier with electric hoist attached, for picking up the load at one point and transporting it to destination on overhead tracking system without re-handling.

Suspension system shall comprise hanger rod assemblies with ball-and-socket or T-type joints, flexibly constructed so that carrier wheels always contact rail on each side. Rail shall be sufficiently thick to carry load and provide for wear with safety factor of 5.

Hoist and trolley shall be of low head room construction to permit maximum lifting and shall comprise standard assemblies with interchangeable parts. Hoist ropes shall be retained in position in drum grooves by encircling spring-loaded steel rope bands and high grade gun metal rope guards. Rotating shafts shall be splined to receive gears and mounted on ball journals. Gears shall be protected by readily removable sheet steel covers.

System shall be moderate duty with rated lifting capacity as required, 10 meters standard lift and lifting speed 8 meters per minute with 10% creep speed.

Trolley hoist shall be electrically operated, self-aligning, low head room type comprising hoist and trolley in compact unit designed to run on lower flange of I-beam with travelling speed of trolley 20 meters per minute.

Lifting mechanism shall comprise shock resistant steel frame, with suspension members and covers, gear drive system, positive action load brake, lifetime lubricated and sealed bearings and drop forged alloy swivelling and rocking load safety hook.

Trolley shall be electrically driven, with size to fit I-beam girder and with alloy cast iron wheels heat treated and machined to uniform diameter mounted on sealed, heavy duty, precision, anti-friction roller or ball bearings lubricated for life. Trolley brakes shall have 50% torque.

Hoist motion brakes shall stop motion under all service and weather conditions, with lining material producing constant coefficient of friction, not wearing rapidly and not scoring. Brakes shall have 150% torque of nameplate rating of hoist motor.

Controls shall be selective push-button control for floor operation with emergency stop button and designed to NEMA Standards.

Electrical motors shall be totally enclosed, fan cooled, squirrel cage type, weatherproof and tropicalized (IP56 Class F insulation) for operation in ambient temperatures up to 50 deg. C.

Steel surfaces shall be factory painted with one coat etch primer and one coat gloss finish paint.

Safe working load shall be clearly marked in large print on unit in English and local language.

2702.05 STAND-BY DIESEL GENERATOR SETS

2702.05.1 General

Scope: The work covers the supply, installation, commissioning, testing and hand-over in good operable manner including two years guarantee and maintenance of 415 V automatic start on mains failure of standby diesel generator set as indicated on the Drawings. The set shall be complete with diesel engine, generator, control panel, batteries, starting motor, air cooled radiator, daily fuel storage tank, earthing system and all other accessories as specified and required to complete the work.

Climatic Conditions**:** Climatic conditions in Kuwait are severe. During summer ambient shade temperature can rise to52°C , and drops to -6^{o} C . during night in winter. Sun temperature can reach 84^{o} C as recorded on black bulb thermometer. High temperatures are usually accompanied by low humidity but periods of high humidity are common and humidity of 100% has been recorded at a shade temperature of 30 ^{o} C Violent sand and storms occur with speed in excess of 100 km/hr . and even on comparatively still days fine dust is suspended in the atmosphere.

2702.05.2 Applicable Standards

Engines shall conform to BS 5514. Alternators shall conform to BS 4999.

2702.05.3 Submittals

Shop Drawings**:**

The Contractor shall submit 3 copies of shop drawings for approval. Shop drawings shall be complete, as to be as-built drawings, not general outline drawings used for sales and guide layouts.

A complete wiring diagram for the generator set shall be submitted, drawn on a single standard size sheet, showing the following:

1. All components of:
    a. Engine starting control
    b. Engine alarm
    c. Generator control
    d. Battery
    e. Battery charger
    f. Earthing
2. Interior wiring, terminals and interconnecting wiring.
3. Certified dimensions and weights.

The Contractor shall submit a composite wiring diagram of the entire emergency transfer system showing all wiring between the engine starting panel, engine generator set and the automatic transfer switches.

Wiring diagrams shall clearly show:

1. Main current conductors, in heavy lines.
2. Control conductors, with colour and/or number coding.
3. Location of relays and apparatus.

4. Description of function, type and catalogue, of all components.

The Contractor shall also submit the alternator Control Panel, and a schematic line diagram showing:

1. Interlocks
2. Protection
3. Instruments

Service Facilities**:**

The Contractor shall indicate the nearest location from which service facilities and spare parts may be obtained after the guarantee period.

Test Reports**:**

The Contractor shall submit certified copies of data obtained during factory test of the engine generator test.

Operation and Maintenance Data:

The Contractor shall submit certified copies of data obtained during factory tests of the engine generator test including:

1. Manuals for generator set.
2. Detailed instruction books.
3. Operator's manuals.
4. Maintenance schedules.
5. Part catalogues.

The Contractor shall also submit 3 copies of the following:

1. Complete instruction covering the operation of the engine generator set and associated equipment.
2. A manual covering engine operation and maintenance.

One copy of the composite wiring diagram of the emergency transfer system shall be fixed inside the transfer switch compartment door and another in the generator control panel.

Spare Parts**:** The Contractor shall provide the spare parts as indicated in this Section properly preserved and packed in a suitable carton box marked "Spare Parts: Engine Generator Unit".

Product Delivery, Storage and Handling**:**

All generator equipment shall be lifted using eyes, yokes and skids provided by the manufacturer. Equipment assemblies shall not be stored exposed to weather.

All generator equipment shall be physically protected against damage from work of other trades, and shall be covered with suitable material to avoid damage to finish.

Submittals

All submittals shall be in the English language

2702.05.4 Materials

A. Generator set:

The set shall be of rugged reliable design and built for long trouble-free service under the worst specified climatic conditions and made by an approved reputable manufacturer.

The rated output shall be as indicated on the Drawings, 240/415 Volts,
3 phase and 50 Hz. The rated output shall mean the net full continuous de-rated output in Kuwait at ambient temperature up to 52^{o}C at relative humidity 50%. The set shall also be capable of 110% load for one hour under these conditions at the rated speed without undue heating of the engine or alternator and without mechanical or electrical troubles.

A.1 Diesel Engine:

1 The diesel engine shall be of stationary heavy duty, turbo charged compression/ignition, multi-cylinder 4 stroke operation. The steel base frame shall be provided with surface hardened rubber neoprene type vibration isolators, located in strategic nodes below the equipment and above the skid. The engine shall be able to deliver full load in the shortest possible time after start. The engine speed shall not exceed 1500 r.p.m. The engine construction shall be in such a way as to allow for dismantling of any engine component for inspection or repair without undue complication i.e. without dismantling of other non-defective parts. The crank-case shall be provided with inspection windows.

2 Starting System: The diesel engine shall be equipped with battery starting system detailed hereunder and as per Engineer's approval.

- The engine shall be started by a 24V, D.C. starting motor automatically engaging with engine flywheel and positively disengaging on engine starting.
  The engine starting control equipment shall be arranged to disconnect the battery charger to prevent it from being over-loaded during starting. The starter motor shall be of adequate power of its duty.

- Batteries for starting shall be of the nickel cadmium type, 24V, heavy-duty diesel starting type and of sufficient capacity to provide continuous cranking of 1.5 minute duration without recharging. Batteries should have sufficient capacity to provide three successive starts.

- The batteries shall be filled with electrolyte and installed on proper racks with cables and clamp. A hydrometer shall be supplied with the batteries.

- The battery charger shall be static type enclosed in an adequately ventilated sheet steel case and incorporated within the control panel with its associated instruments and controls mounted on front of panel. The battery charger shall be manufactured by the same manufacturer as that of the Diesel generator set.

- The charger shall be complete with all necessary relays, cut-outs, controls, switches and instruments for automatic charging of batteries. The charger shall automatically control the charging rate to suit state of battery thus charging at high rate following a period of use of battery and, when battery nearly fully charged, reverting to trickle charging automatically.

- An ammeter and voltmeter on the front of panel shall indicate the state of the battery and its charging rate.

3 Cooling System:

- Radiator: Set mounted type sufficient capacity to dissipate the total joules per hour rejected by the engine cooling system at 110% full load.
- Fan for Radiator: To have sufficient pressure to circulate required quantity of air for engine cooling. The fan shall be provided with a suitable guard. Diesel generator (D/G) room's inside temperature should not exceed a differential of 30 Deg F with respect to the ambient temperature. Ventilation calculation shall be submitted for approval by the Engineer.
- Jacket water heaters: To be provided on engine to facilitate quick heating under low ambient conditions.
- The cooling system shall be capable of keeping the temperature of cooling water at safe limits at all conditions of load required in the Specifications. Maximum temperature of cooling water after 10 hours of continues running at full load at worst Kuwait climatic conditions shall not exceed the maximum temperature limits of the diesel engine.

- The cooling system shall include an engine shaft driven circulating water pump. The water jacket of the engine cylinder shall be so constructed that the water in the jacket can be drained completely.
- The radiator finned tubes shall have a common inlet and common outlet headers.
- A drain valve and a filling valve shall be provided to the radiator for flushing and quick filling.

4. Fuel System:

a. Shall be suitable for running on diesel oil as described below:

Specific gravity at 60F distillation (P. P.123/40)	: 0.834
IBM	: 219 C
10%	: 250 C
SO%	: 276 C
90%	: 314 C
F.E.P.	: 342 C
Flash Point PME	: 189 C
Sulphur	: 1.1 %
Calorific value B.T.U./lbs gross	
Carbon residue	: 19750
0.01/wt diesel index	: 62
Viscosity redwood seconds at 100F	: 34

b. Daily Fuel Tank:

Fuel supply to the engine shall be maintained by a separate day tank located in the room. Daily fuel tank shall be sufficient capacity for continuous run of 8 hours at full load, and shall be fitted with control cocks, drain cock, integral electric pump to supply fuel to the engine, piping to the engine and a level indicator with alarm contacts, vents and all other necessary fuel lines and fittings.

c. Underground Fuel Tank:

Underground tank is to be cylindrical tank with long radius convex ends, of 6mm thick high quality, black steel plate welded on internal and external seams and hydro-statically tested at factory to a pressure of one atmosphere for 24 hours with welds proven sound. Manhole 600mm diameter with 6mm sides and flanges is to be welded to top of tank. Manhole cover is to be fitted to flange with 1.6mm gylon composition ring gasket and long machine bolts and nuts equally spaced.

Tank including manhole and connection are to be cleaned of rust, scale welding slag, oil, grease and foreign matter by sand blasting or wire brushing down to base metal and painted on outside with two coats zinc chromate primer and two coats acid and alkali resistant protective coating. Two coats of bitumen are to be added for underground installation.

Tank inlet valve shall be protected against vehicular impact by means of bollards from all sides of vehicular access. Bollards shall be of welded steel construction, powder coated, safety yellow finish with removable rubber caps. Base plates shall include four pre-drilled mounting holes.

The underground fuel storage tank and its housing chamber shall be according to the Kuwait National Petroleum Company (KNPC) standards. The Contractor shall obtain the approval of the KNPC before commencing the Works on site.

d. Fuel Oil Piping:

Provide all diesel fuel oil piping from day tank to engine and from the main underground tank to the day tank and from the diesel fuel supply point to the main underground tank.

All piping shall be provided with ground joint unions at piece of apparatus to facilitate connecting and disconnecting.

All piping, unless otherwise specified, shall be schedule 40 standard weight black wrought iron pipe.

Steel vent pipelines shall run from the fuel oil storage tanks, carried to the proper height within building construction and terminating with vent fittings. Fittings shall be "Bronze Ventilating Brick" with thickness of 20 mesh bronze wire gauge in front of louvered opening.

e. Fuel Transfer Pump:

Type: comply with UL 343. Pump to be rotary gear type, positive displacement, designed to handle all grades of fuel oil. Pump to have steel gears, steel shaft, mechanical seals, cast-iron housing, steel base, and drive coupling. Pump to be self-priming and quiet in operation.

Drive: V-belt drive with belt guard or direct drive, close coupled.

Motors: TEFC, induction type and explosion proof with permanently lubricated and sealed bronze ball bearings.

Accessories: to be supplied complete with built-in pressure relief bypass, bronze gate valves, bronze check valves, duplex strainer with each pump, drip tray with drain plug, pressure gauges on suction and discharge. All valves and accessories to be suitable for fuel oil applications.

-Materials: gate valves and check valves to comply with MSS SP-80, Class 125, to be bronze body, suitable for fuel oil service, with "WOG" indicated on body.

Sight Glass: provide sight glass suitable for fuel oil application on suction line of pump

Pumps shall be supplied with a control panel to control the operation of the pumps based on level sensors in the generator daily fuel tanks. The control panel shall house the following features:

1. IP-55 enclosure
2. Main isolating switch mechanically interlocked to front door to prevent access to live parts.
3. Motor starters.
4. Level controllers.
5. Alternator / Sequencer of pump starting.
6. Indicator lights and monitoring points as follows:
    a. Pump on / Pump off
    b. Pump tripped
    c. Pump selector switch not on auto
7. Interconnecting and interlock wiring.

5. Lubricating System:

- The lubricating oil system shall be forced fed type. The details of the system shall be submitted for approval. The shaft bearing lubricating shall be directly fed from the lubricating oil pump and not through the main bearings.
- The lubricating oil shall be of a type readily available internationally and in Kuwait.
- The lubrication system shall be positive displacement type. By-pass arrangement should be provided in case of filter clogging.
- A heat-exchanger shall be provided for cooling the lubricating oil and this shall be of long-life type i.e. the system shall not require constant cleaning or other maintenance work. A valve for taking oil sample shall be provided. The coolant for the above shall be jacket water of the engine. That is

the cooling system of the engine and the lube-oil heat-exchanger cooling system shall work in parallel or in series. If the lube-oil pressure reaches low value, the engine shall be shut down automatically and also immediately should give audible alarm together with visual at important points at the engine-monitor panel.

- Suitable manual-pumping arrangement for easy draining of the whole quantity of lube-oil into a drum shall be provided.

6. Exhaust System:

- Exhaust pipes shall be of Schedule 40 black for easy steel and of adequate size to ensure that back pressure does not exceed the value specified by the manufacturer.
- The exhaust pipe shall be connected through airtight flexible coupling to the engine.
- Exhaust pipes shall be adequately lagged with 50 mm thick (minimum) rock wool covered with aluminium sheaths so that to take care of exhaust gas temperature in pipes exceeding 500°C. When exhaust pipes pass through walls or roof a suitable weatherproof sleeve or thimble shall be provided to isolate exhaust pipe from the building. A silencer of heavy duty residential type shall be provided in the exhaust system and it shall also be lagged. The operation of casting the sleeves in the concrete, if required, will be part of the civil works.
- Exhaust pipes and silencers shall be supported from the ceiling and the pipe shall be slanted away from the engine and a condensate trap fitted at the lowest points. Approved rain caps shall be installed at the discharge end of the exhaust pipes on the roof.
- Suitable flexible expansion joints shall be provided along the pipe run to take care expansion requirements.

7. Filters:

Cleanable/replaceable elements should be provided.

a. Fuel Oil System:

- The system shall have the following filters fitted before the fuel injection pumps:
- A primary fuel filter of ample capacity to prevent all particles of 10 microns size or smaller.
- A secondary filter to prevent all particles down to 3 microns size or smaller.

b. Lubricating Oil System:

- This system should have full flow filters of sufficient capacity.
- The Contractor shall give full particulars of the filters used. It shall be mentioned if filter elements are cleanable or replaceable, in which case, the working hours after which the element and the lubricating oil is to be replaced should be stated.

c. Intake and Exhaust System:

Air is inducted to the engine manifold through:

- Pre-cleaner.
- Large capacity air cleaner: Both filters are required due to severity of dust suspensions in the air and shall be heavy duty. The engine exhaust line shall be fitted with flexible fitting efficient silencer to give efficient silencing with minimum back pressure and terminated outside the engine room.

8. Ventilation:

Ventilation shall be through negative pressure system, which includes Metal louvers with metal cleanable filters. Filters shall be permanent heavy duty metal cleanable type minimum 2" (50mm) thickness. Filters to be sized to perform their duty with a face velocity not more than 400 fpm when engine is running. Filters to be installed in an appropriate arrangement. Total filter area shall consider air for engine intakes and radiators cooling. Filters with handles and latches shall be provided.

9. Governing System:

- The engine shall run steadily at any load within its rating at its rated speed, and the changes in speed due to change in load shall comply with BS 5514/77 for Class A1 or with ISO 3067.
- The governor should be of the electronic type to comply with BS 5514/77 Class A1.

10. Coupling and Common Bed:

- The engine and the alternator shall be suitably coupled directly without interposing gear arrangement.
- The common bed shall be provided with suitable damping devices with factory assembled surface hardened neoprene rubber isolation for maximum efficiency, located at strategic points for maximum vibration arrest.
- The engine vibration shall be the minimum possible and shall comply with the relevant BS. The vibratory force induced as the engine passed through resonance revolutions during starting and stopping period shall not cause any damage to the whole system.

11. Engine Monitor Panel:

a. Each engine shall be provided with a monitor panel adequately isolated from vibration, which shall contain facility to monitor the following:
- Engine speed.
- Temperature of oil, coolant.
- Lubrication oil pressure.
- Engine operation hour counter.
- Other required items.

b. The engine shall be able to operate manually from the monitor panel. Manual speed control facility shall be provided.

A.2 Alternator and Exciter:

The alternator shall be able to withstand the stresses caused by the sudden application of the loads.

a. Type: PMG excited, self ventilated, air-cooled, splash-proof, synchronous alternator.
b. Output: As indicated on Drawings at Kuwait rating.
c. Voltage: 415V
d. Frequency: 50 Hz.
e. No. of poles: 4
f. No. of phases: 3, (neutral to be brought out).
g. Power factor: 80% lagging.
h. Commercial efficiency not less than 90% (including excitation and field losses).
i. Voltage regulation: Automatic and static

Class "H" insulation shall be applied to stator, rotor and exciter windings.

The alternator shall be suitable for continuous running duty type S1, BS 2613 (latest edition).

Distortion of no-load voltage wave form at alternator terminals shall be within 5% from the sinusoidal wave form.

Voltage adjustable range of the output voltage by adjusting the exciter shall be not less than 3% of rated voltage at rated load and not less than $\pm$ 5% of rated under no-load conditions. This adjustment shall be able to be performed from panel mounted handle or knob.

The voltage of the alternator shall be automatically controlled by electronic static circuits.

The alternator shall not be switched on the load until terminal voltage has reached at least 90% of the nominal value. It is essential that the voltage regulation equipment shall have sufficient fast response time so that the alternator is ready to accept load in the shortest possible time.

The voltage regulator shall be designed to maintain the alternator terminal voltage constant within ± 1% of the nominal value from no load to full load within normal variations of engine speed with change in load.

The exciter shall be brushless, self excited, and rotor mounted type. The rectifying elements shall be silicone.

The unit shall be suitably protected so that when there is a sudden variation of load, the sudden increase of field current in the rotor shall be curtailed and thus the speed build up of the engine and the voltage build up of generator shall vary proportionately.

Terminals with cable end boxes shall be provided respectively for the alternator and exciter.

The cooling air for alternator and exciter shall be drawn through openings at the non-drive end and exhausted sideways at the driving end.

The alternator shall be fitted with air-condensation heater to keep the winding in good, dry and safe condition. The air-condensation heater shall be automatically cut-off when the machine is running. Necessary on-off switches shall be provided on the control panel and the operation status of the heater shall be indicated.

Temperature Rise: Alternator components shall be sound electrically and mechanically in continuous operation lasting over 24 hours at the rated output.

Insulation Resistance: Insulation resistance of the machine at strategic points shall be submitted with the shop drawings.

Dielectric Strength: The dielectric strength, the voltage of testing and test procedure at various points of the machine shall be submitted with the shop drawings.

Vibration: Vibration at the fixed components of the alternator under excited no-load operation shall be as per relevant BS.

Terminal Symbol:

- Terminal symbols for the alternator shall be in accordance with BS 822 requirements.
- The alternator shall be provided with protection against over speed, over voltage, over current, short circuit, reverse power, earth fault and any other found necessary. The neutral points of alternators shall be solid by connecting to earth

Panel Wiring:

- All wiring of battery charger, exciter and control panel shall be P.V.C. tropical grade of adequate current carrying capacity to prevent over-heating under worst climatic conditions.
- All wiring shall conform to the relevant BS and at least 50% de-rated with minimum size of 2.5 sq. mm. or its equivalent.

Terminal Board:

- Terminal boards shall have pairs of terminals for Incoming and Outgoing wires and not more than two wires shall be connected to any one terminal.
- Insulating barriers shall be provided between adjacent connectors. Labels for wiring designation marks shall be provided on the fixed portion of the terminal boards as well as wires. No live metal shall be exposed at the back of the terminal boards.
- Terminal boards having pressure type terminal lusts or equivalent shall be used so that no terminal clamp is necessary. 10% spare terminals shall be provided for each terminal board assembly.

B Control Board:

B.1 Cabinet:

- Sheet steel construction, totally enclosed, dust protected and vermin proof.

- A hinged, lockable door shall give access to control and instruments.
- "Live" parts shall be secured to prevent inadvertent contact with them.
- Controls for diesel engine, alternator, exciter, meters and alarm device shall be positioned to give ample space for removing and installing components.

B2 Instrument in Control Board:

The generator set shall be provided with a microprocessor-based control system, which is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this Specification.

The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

The control shall be UL-508 listed, CSA-282-M-1989 certified, and meet IEC-8528 part 4. All switches, lamps and meters shall be oil-tight and dust-tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts. The controls shall meet or exceed the requirements of Mil-Std 461C part 9, and IEC Std 801.2, 801.3, and 801.5 for susceptibility conducted and radiated electromagnetic emissions. The entire control shall be tested and meet the requirements of IEEE-587 for voltage surge resistance.

The generator set mounted control shall include the following features and functions:

a. Three position control switch labelled RUN/OFF/AUTO. In the RUN position the generator set shall automatically start, and accelerate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

b. Red "mushroom-head" push-button EMERGENCY STOP switch.
Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.

c. Push-button RESET switch.
The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

d. Push-button PANEL LAMP switch.
Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

e. Generator Set AC Output Metering:

The generator set shall be provided with a metering set including the following features and functions:

- 2.5-inch, 90 degree scale analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter. These meters shall be provided with a phase select switch and an indicating lamp for upper and lower scale on the meters. Ammeter and KW meter scales shall be colour coded in the following fashion: readings from 0-90% of generator set standby rating: green; readings from 90-100% of standby rating: amber; readings in excess of 100%: red.

- Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.

f. Generator Set Alarm and Status Message Display:

The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing alarm and shutdown conditions. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions.

The generator set control shall indicate the existence of the following alarm and shutdown conditions on a digital display panel:

- Low oil pressure (alarm)
- Low oil pressure (shutdown)
- Oil pressure sender failure (alarm)
- Low coolant temperature (alarm)
- High coolant temperature (alarm)
- High coolant temperature (shutdown)
- Engine temperature sender failure (alarm)
- Low coolant level (alarm or shutdown-selectable)
- Fail to crank (shutdown)
- Over crank (shutdown)
- Over speed (shutdown)
- Low DC voltage (alarm)
- High DC voltage (alarm)
- Weak battery (alarm)
- Low fuel-day tank (alarm)
- High AC voltage (shutdown)
- Low AC voltage (shutdown)
- Under frequency (shutdown)
- Over current (warning)
- Over current (shutdown)
- Short circuit (shutdown)
- Ground fault (alarm) (optional when required by code or specified)
- Over load (alarm)
- Emergency stop (shutdown).

In addition, provisions shall be made for indication of two customer-specified alarm or shutdown conditions. Labelling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions.

The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

g. Engine Status Monitoring:

The following information shall be available from a digital status panel on the generator set control:

- Engine oil pressure (psi or kPa)
- Engine coolant temperature (degrees F or C) both left and right bank temperature shall be indicated on V-block engines.
- Engine oil temperature (degrees F or C)
- Engine speed (rpm)
- Number of hours of operation (hours)
- Number of start attempts
- Battery voltage (DC volts)

Control

- The control system shall incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads as a percent of the standby rating of generator set.

- The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and 3 of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.

- The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.

- The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this Specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

- The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature, which is capable of discriminating between failed senders or wiring components, and an actual failure conditions.

- The control system shall include all interfaces necessary for proper operation with the paralleling equipment provided under this Contract. The generator set supplier shall be responsible for complete compliance to all specification requirements for both the generator set and the paralleling equipment.

Alternator Control Functions:

- The generator set shall include an automatic voltage regulation system, which is matched, and prototype tested with the governing system provided. It shall be immune to disoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase RMS sensing and shall control build-up of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of [58-59] HZ. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off.

- Adjustments shall be broad range, and made via digital raise-lower switches, with alpha-numeric LED readout to indicate setting level. The voltage regulation system shall include provisions for reactive load sharing and electronic voltage matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.

- Controls shall be provided to monitor the output current of the generator set and initiate an alarm when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator.

- Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition when total load on the generator set exceeds the generator set rating for in excess of 5 seconds.

- Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.

- An AC over/under voltage monitoring system, which responds only to true RMS voltage conditions, shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

- A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25 VDC or more than 32 VDC. During engine starting, the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.

- When required by National Electrical Code or indicated on project Drawings, the control system shall include a ground fault monitoring relay. The relay shall be adjustable from 100-1200 amps, and include adjustable time delay of 0-1.0 seconds. The relay shall be for indication only and not trip or shut down the generator set. Note bonding and grounding requirements for the generator set, and provide relay which will function correctly in system as installed.

Control Interfaces for Remote Monitoring:

All control and interconnection points from the generator set to remote components shall be brought to a separate connection box. No field connections shall be made in the control enclosure or in the AC power output enclosure. Provide the following features in the control system:

a. Form "C" dry common alarm contact set rated 2A @ 30 VDC to indicate existence of any alarm or shutdown condition on the generator set.

b. One set of contacts rated 2A @ 30 VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.

c. A fused 10 amp switched 24 VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.

d. A fused 20 amp 24 VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.

Controls which are essential as minimum

The following controls are essential requirements for the protection and best performance of the emergency Diesel generator system. The Diesel generator supplier shall provide a compliance statement for the following essential controls in order to have the fail proof emergency system. The Diesel generators, which do not meet any one of the following control requirements, shall not be accepted.

a. Control equipment shall contain a system of diagnostic Digital alpha numeric bright lit LED’s to assist in analyzing proper system function.

b. Controls shall include three phase sensing reverse power equipment, to prevent sustained reverse power flow into the generator set.

c. Electronic alternator over current alarm and shutdown protection. This protection is required in addition to the over current trip on the main breaker. The over current alarm shall be indicated when the load current on the generator set is more than 110% of rated current for more than 60 seconds. The over current shutdown shall matched to the thermal damage curve of the generator set, and shall not have an instantaneous function.

d. Electronic alternator short circuit protection as built in function of the control panel microprocessor control logic. This protection is in addition to the over current trip on the paralleling breaker. The short circuit shall occur when the load current on the generator set is more than 175% of rated current and an aggregate time/current calculation indicates that the system is approaching the thermal damage point of the alternator. The equipment used shall not have an instantaneous function.

e. Controls shall be provided to sense loss of excitation of the alternator while paralleled to the system bus.

f. Controls shall be provided to adjust number of starts and starting and rest period duration.

g. Fuel ramping control to reduce black smoke at starting.

h. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25 VDC or more than 32 VDC. During engine starting, the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.

i. Generator set start contacts rated 10 amps at 32 VDC.

j. Cool down time delay, adjustable: 0-600 seconds. The control panel shall indicate the time remaining in the time delay period when the generator set is timing for shutdown.

k. Start time delay, adjustable: 0-300 seconds. The control panel shall indicate the time remaining in the time delay period when the generator set is timing for start.

l. The control system shall monitor the paralleling breaker auxiliary contacts, and initiate a fault signal if the breaker fails to close within an adjustable time delay period after the control has signalled it to close (0.5-15 seconds). Breaker failure alarm shall cause the paralleling breaker to trip open, and lock out until manually reset.

m. Controls shall be provided to initiate an alarm condition when generator set is at 90% of rated frequency for more than 20 seconds.

n. Controls shall be provided to shut down generator set and initiate alarm when the generator set is at less than 85% of nominal voltage for more than 15 seconds, more than 110% of nominal voltage for more than 10 seconds, or more than 130% of nominal.

C. Automatic Transfer Switch (A.T.S.):

The ATS shall comprise of 2 Nos. 3 phase 4 pole mechanically and electrically interlocked air circuit breakers, MCCB's contactor as shown on the Drawings.

For the ATS necessary manual change-over switches shall be provided to by-pass the ATS in case of maintenance or repair as shown on the Drawings.

The arrangement, wiring and components shall satisfy the requirements of the Diesel Generator manufacturer. His written approval shall be submitted.

Control voltage of ATS shall be normally fed from the main supply, in case of failure of the main supply it shall be fed automatically from the emergency supply.

In addition to transfer switches, the ATS arrangement shall be equipped with the following:

1. A selector switch to control the operation of ATS on normal, emergency, automatic and OFF.
2. Adjustable 3 phase voltage sensing relays sense failure in one phase or phases and voltage drop below 70% of the normal voltage (pick-up and drop-out voltages and adjustable within the range of 70 - 100% of the normal voltage.
3. Adjustable frequency sense to sense under frequency to 46 Hz.
4. Visual mechanical indicator for transfer switch position.
5. Indicator lamps to show transfer switch position normal, emergency and OFF.
6. An adjustable delay relay of 1 - 3 seconds for starting signal to the Generator set after cutting of main supply. One phase failure, under voltage or under frequency.
7. Adjustable time delay relay of 0 - 3 second which allows ATS from normal to emergency after the voltage build up relay of the generator has sensed 90% rated voltage when frequency within 99% rated or rated frequency.
8. An adjustable time delay relay of 0 - 1 minutes to allow ATS from Emergency to Normal.
9. An adjustable time delay relay of 0.5 - 5 seconds to prevent instantaneous transition from Emergency to Normal i.e. the delay allows time sufficient for the residual motor voltage to decay to a safe switching level.
10. An adjustable time delay relay of 1 - 5 minutes to allow the engine to shut-down after a cool down unload time delay after ATS has been switched to normal position.
11. The ATS shall be equipped with 8 sets auxiliary contacts - 4 Nos. Normally opened and 4 Nos. Normally closed for transferring functions as herein specified and other functions requested by generator sets supplier.

The ATS shall be approved by the Kuwait Ministry of Electricity and Water (MEW) before they supply power to it.

D **Manufacturers:**

1. Cummins Power Generation (Cummins-Onan), USA.
2. Caterpillar Tractor Co., USA.
3. Mitsubishi, Japan.
4. Approved Equal.

2702.05.5 System Operation

Loss of Normal Power: System is given signal to start by receipt of start signal from automatic transfer switch or other remote device. On receipt of this signal, generator set automatically and independently starts accelerate to rated frequency and build up to rated voltage. The first start system monitors this process, and on finding a generator set at 90% of rated voltage and frequency, automatically closes the unit to the bus. This time transfer switch begin the time delay transfer sequence, and on its completion transfer their loads to the system bus.

Failure of a Unit to Start: If a unit fails to start, after the over crank time delay (in the generator set control) has expired, the unit will be shut down, and an alarm will sound.

Return of Normal Power: When all of the systems start signal is removed from the generator set and the generator set shall operate at no load for a cool down period. When the cool down period has been completed, the generator set shall shut down. If a system start signal is received during the cool down period, the generator set shall immediately close to the emergency bus as described in "Loss of Normal Power" above.

Distribution Equipment: Provide output circuit breaker of the number and size as shown on the project Drawings. The breakers shall have an interrupting rating as indicated on the Drawings.

2702.05.6 Commissioning

Simulated Power Failure Test - Engine: Generator shall be made ready for automatic operation and started by means of the test transfer switch on the automatic transfer switch. Unit shall run for the duration of all time delays and then automatically shutdown. This test shall be made with unit operating, and twice with unit simulated for a starting failure.

Testing of the Set:

A. Engine:

1. The engine shall be tested at site before and after erection to BS BS ISO 3046 and amendments or equivalent including items, which are said to be subject to mutual agreement.
2. Subsequent running test of eight hours shall be carried-out of the set.
3. The engine shall be subjected to vigorous performance tests at site under the worst environmental conditions prevailing here to the satisfaction of the Engineer and the main items shall include:
   a. Output characteristics at various load conditions.
   b. Temperature rise measurement at various loads.
   c. Checking of valve clearance, fuel pump setting, governor setting, pipeline connections, and exhaust piping and flexible connections.
   d. Checking the base and set are level in all directions, checking alignment of engine and generator and vibration isolators' location and proper installation.
   e. Checking or proper operation of engine safety devices.
   f. Checking of fuel pipelines, fuel pumps, tank level gauges and level control switches operation.

B Alternator and Exciter:

1. The alternator and exciter shall be tested to BS 5000 P.99 amendments thereof.
   Tests at site before erection and after erection prior to handing over shall be carried out to the satisfaction of the Engineer. The main items of tests deemed necessary by the Engineer shall be carried

out at the expense of the Contractor. The performance test shall be for 24 hours under the worst climatic conditions prevailing in Kuwait.

2. The Contractor shall be fully responsible to provide all the necessary facilities for the test at his own expense.

System Responsibility: The generating set, switchboard and automatic transfer switches shall be interconnected according to pump stations load requirements and to manufacturer's recommendations, to prevent the emergency generating system from stalling or faltering due to momentary overloads beyond system rating, from distribution faults, motor starting loads.

C. Training for Operation and Maintenance Personnel:

The Contractor shall train a number of persons who will be selected by the Engineer for the operation and maintenance of all the works within the Contract before these works are handed over to the Employer

The training has to be carried out by qualified staff of the Contractor for each specified service and shall be maintained for a one month period following on the Certificate of Completion.

D. Maintenance Period**:**

During the maintenance period of 24 months ,unless a longer period is required by the Contract Documents, the Contractor shall repair and replace directly, at his own expense, any of the plant, material or work performed or furnished under the respective works in the Contract which may develop under the conditions provided for by the Contract and under proper use in the works or that portion thereof taken over by the Employer.

The Contractor shall obtain and submit to the Engineer all guarantees or certificates or warranty available from the manufacturers, but only as supplementary to the Contractor's own liabilities under the Contract and in no way invalidate them.

The Contractor shall be fully responsible for the satisfactory operation of the Diesel Generator (D/G) installation during the Maintenance and Guarantee Period. He shall carry out necessary inspection, preventive maintenance and testing to keep the set ready all the time. The set shall function satisfactorily during power failures.

The Contractor shall carry out routine testing of the installation once in every two weeks throughout the maintenance and guarantee period. The testing shall be carried in presence of Engineer or the eventual operator. The Contractor shall himself provide all electrical and mechanical spare parts, grease, lubricating oils, touch-up paints etc., required for the maintenance of the D/G installation. The Contractor shall prepare log-books listing full details of maintenance work and each log-book entry shall be countersigned by the Engineer or the eventual operator.

2702.05.7 Execution

A. General**:**

The engine and generator shall be properly aligned and mounted on a common steel base to prevent vibrations. The whole set shall be fixed on the concrete slabs through suitable vibration pad. Foundation and other builder's work shall be as recommended by the manufacturer and approved by the Engineer.

Except as may be described in this Section or shown on the Drawings; installation shall be carried out strictly in accordance with the manufacturer's recommendation.

All outgoing cables from the generator to the control boards shall be run in the floor trench as indicated on the Drawings.

B. Paint Work:

Paint work of each set shall be of the highest quality to withstand the worst weather conditions specified. All steel works such as tanks, pipes, frames, louvers, ladders, platforms, etc, shall be given two undercoats of anti-rust paint and two enamel finishing.

C. Site Quality Control Testing:

shall be carried out at full load after completion of installation by the Engine manufacturer's qualified representative in the presence of the Engineer.

2702.06 VENTILATION AND AIR CONDITIONING SYSTEM

SPLIT ROOM AIR CONDITIONERS

A. Split Room Air Conditioners: Unit shall comprise of an indoor unit and an air cooled outdoor unit for application with R-134A refrigerant. The air conditioning unit shall be capable of handling the cooling loads when operating at the ambient design conditions at the medium fan speed.

B. Indoor Unit:

-Cabinet to be of the decorative type for exposed usage and to be constructed of finished steel with baked resin paint. The cabinet interior to be fully insulated to prevent sweating and to muffle the sound. (Cabinets made partly out of plastic shall be acceptable).

-Evaporator coil shall be multi-pass cross finned tube equipped with aluminum plate fins, mechanically bonded to seamless oxygen - free copper tubes. The coil shall be cleaned, dehydrated and tested for leakage at the factory. Coil face velocity shall not exceed 2.5 FPM.

-Evaporator fan to be forward curved centrifugal type, statically and dynamically balanced and directly driven by the motor. The fan motor shall be permanently lubricated. The evaporator fan must be selected to operate quietly with no overloading of fan motors.

-Air filter to be washable type, long life as per manufacturer's standard.

-Refrigerant circuit to have one-shot couplings or isolating valves at liquid inlet and gas outlet, a capillary tube and a strainer.

-Drain pan to be sturdy metallic, treated for corrosion resistance, insulated and easily accessible for cleaning/maintenance.

-Sound level not exceed NC 30 at low speed and NC 35 at high speed when measured at one meter distance in a room with normal occupancy and furnishing.

C. Unit Control: unit shall be equipped with an operation switch, fan speed selector switch and a thermostat mounted on the control panel. The control system shall permit manual starting and automatic continuous operation whenever the thermostat requires and the protection devices allow.

-The ceiling/wall suspended unit shall be equipped with remote type control box having thermostat, OFF/FAN/COOL and speed selection switch. Thermostat of the type lockable at the extreme setting shall not be acceptable.

D. Outdoor Unit:

- Outdoor unit to be factory assembled, piped internally, prewired and shall be designed to operate at outdoor design ambient temperature.

- Cabinet to be constructed of finished steel with baked synthetic resin paint. The fan guard shall be adequately protected against corrosion.

- Unit to contain a hermetic compressor with internal suspension and welded shell. Suitable vibration isolators shall be provided external to the compressor.

- Condenser coils to be multi-pass cross-finned type equipped with aluminum plate fins mechanically bonded to seamless copper tubes. The coil shall be cleaned, dehydrated and tested for leakage at the factory.

- Condenser fan to be propeller type with aluminum blades, statically and dynamically balanced and driven directly by fan motor for up-flow or side-flow air discharge as shown on drawings. The motor shall be permanently lubricated and shall be protected from water invasion.

- Refrigerant circuit to have one shot couplings or isolating valves at liquid outlet and gas inlet.

- Rubber pads for vibration isolation shall be not less than 10 mm thick.

E. Refrigerant Pipes: copper, insulated, pre-charged from factory.

FANS

A. Roof extract fan, belt-driven type shall conform to the following:

- Fan shall be a twin, belt-driven, centrifugal, spun dome type, designed for roof kerb mounting, fully weatherproofed, all aluminium construction, with solid non-ferrous metal structural members and fasteners.

- The Contractor shall select to give sound levels less than 50 db measured on the A-scale of a standard sound level meter at 3m. from the open fan inlet.

- Fan housing shall be heavy gauge aluminium comprising round spun dome and rolled round trunk section connected to square kerb with smooth spun venturi and designed to provide easy access from roof level to internal parts including motor, V-belt drive and gravity shutters.

- Fan wheel shall be aluminium with backward inclined blades with non-overloading characteristics, keyed and locked to drive shaft, with the whole rotating element precision balanced at factory.

- Shaft shall be mounted on two heavy-duty, self-aligning, permanently lubricated and sealed pillow block ball bearings.

- Motor shall be totally enclosed, squirrel cage, induction type, with permanently lubricated ball bearings and in-built thermal overload protection and mounted on vibration dampeners on slotted base for belt tension adjustment. Sheave to be adjustable to allow field changes in fan speed. V-belt to have automatic belt tensioner.

- Accessories: Fan to be complete with the following: self-closing backdraft gravity shutters, factory wired safety disconnect switch mounted inside housing, flexible tubing to receive field wiring and all-around expanded aluminium bird screen.

- Gravity shutters shall be aluminium blades with felted edges mounted in extruded aluminium frame on stainless steel sleeve bearings. Ship loose for mounting inside concrete kerb.

B. Centrifugal ducted in-line fans shall conform to the following:

- Description: Belt-driven or direct-drive centrifugal fans, as indicated, consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

1. Housing: Removable, spun-aluminum, square, one-piece,

- Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

- Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust air stream.

-Accessories: The following items are required as indicated:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

C. Propeller fans shall conform to the following:

- Description: Belt-driven or direct-drive propeller fans, as indicated, consisting of fan blades, hub, housing, orifice ring, motor, drive, and accessories.
- Housings: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat after assembly.
- Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
- Aluminum blades specified in first 2 paragraphs below are normally used in larger sizes and in higher static-pressure applications.
- Cast-Aluminum Fan Wheels: Replaceable, cast-aluminum blades fastened to cast-aluminum hub. Factory set pitch angle of blades.
- Extruded-Aluminum Fan Wheels: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub. Factory set pitch angle of blades.
- Belt-Driven Drive Assembly: Resiliently mounted to the housing, statically and dynamically balanced and selected for continuous operation at the maximum rated fan speed and motor horsepower (HP), with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor: 1.5.
2. Fan Shaft: Turned, ground, and polished steel keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

a. Ball-Bearing Rated Life: 100,000 hours.

4. Pulleys: Cast iron with split, tapered bushing, dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch. Select pulley so pitch adjustment is at the middle of the adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on the outside of the fan cabinet.

- Accessories: The following accessories are required as indicated:

1. Gravity Shutters: Aluminum blades in aluminum frame, interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent.
7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2702.07 FIRE FIGHTING SYSTEM

FIRE EXTINGUISHERS

A. Wheeled fire extinguishers shall be supplied to each pumping station and shall conform to the following:

- Agent Tank – The extinguisher tank shall be of welded steel construction with two elliptical dished heads and welded circumferential seams. The tank shall be designed and constructed for a working pressure of 250 psi (17.2 bar). The top of the tank shall be fitted with a 4 in. (10 cm) ID (Inside Diameter) fill opening.

- Nitrogen Cylinder and Valve – The nitrogen cylinder shall be mounted in a vertical position. Such mounting shall permit easy access to the cylinder. This cylinder shall be a 110 ft3 (3.11 m3) for the 150-C and a 220 ft3 (6.23 m3) for the 350-C. Both shall be Medical "E" nitrogen cylinders. Each cylinder shall be equipped with a conventional hand wheel nitrogen cylinder valve and visual pressure gauge. A quick-opening valve shall be available as an option. Both valves shall be UL Listed.

- Hoses and Nozzles – The discharge hose shall be UL Listed, equipped with chrome plated brass couplings and 3/4 to 1 in. (2 to 2.5 cm) ID. It shall utilize a pin prick outside cover to permit diffusion of gases. The nozzle shall consist of a two-position ball valve and barrel. The nozzle barrel shall be a three-hole cone tip. The nozzle ball valve assembly shall be chrome-plated brass.

- Nameplates – The nameplate shall be glare-resistant etched aluminum. It shall contain hazard identification plus operating and maintenance instructions.

- Finish – In addition to the standard surface preparation procedures, the steel parts shall be primed using a zinc rich primer with a minimum zinc content of 90%. The top coat shall be an epoxy paint applied as a liquid and oven or air cured. The dry film shall be continuous and a minimum thickness of 5-7 mils. The fill cap and nozzle body shall be black anodized for added corrosion resistance.

- Temperature – Standard models are equipped with nitrogen cylinders which are listed and approved for operation in environments with temperatures between –40 °F (–4 °C) to 120 °F (48.8 °C).

2702.08 INSTRUMENTATION AND CONTROLS

2702.08.1 General

The Contractor shall submit complete control and wiring diagrams for control systems for approval showing control instruments, auxiliaries and accessories.

The Contractor shall provide accessories and appurtenances as necessary and appropriate to accomplish intended control functions, irrespective of whether or not shown or specified, including switches, relays, transformers etc.

The Contractor shall provide control wiring and conduits as necessary and appropriate for complete control systems, to the requirements of this Section as directed by the Engineer.

Indicating instruments including pressure gauges and level indicators shall have range such that normal readings are indicated in middle of instrument range.

Pressure gauges shall have brass cock on inlet.

2702.08.2 Level Controller Type LC-1

Electrode type, using semi-conductor technology, designed to be installed in wet sump, to start and stop pump or to give high or low level alarm signal.

Components shall include rigid electrode and control head with power supply/relay circuit board and heavy duty housing.

2702.08.3 Pressure Gauges

Bourdon tube type, minimum 100mm dial diameter, with flangeless back and 12 mm male threaded bottom connection, and graduated in bars with 0.1 bar divisions.

Components shall include black finished cast aluminum case; threaded black epoxy cast aluminum ring with gasket flash face, type 316 stainless steel spring tube, stainless steel precision movement and micrometer adjustment on needle.

2702.09 ELECTRICAL WORK

Lighting fixture construction – general: comply with the Regulations and Standards for construction. Wiring of fixtures shall be fabricated, assembled and wired entirely at the factory. Site work shall be restricted to reassembling parts dismantled at the factory for transportation. Manufacturer's name, factory inspection stamp and official quality label shall be fixed to each fixture supplied.

Sheet steel for housing shall not be less than 0.6mm thick or heavier.

Sheet steel for reflectors shall not be less than 0.8mm thick.

Light reflecting surfaces shall be finished with white baked enamel paint having a reflection factor not less than 80%.

Wiring shall be not less than 1.5mm², insulated for 240 V applications. Insulation shall be silicone rubber for lower temperatures (fluorescent fixtures) and teflon for higher temperatures (incandescent fixtures). Wiring shall be terminated on screw type, insulated, terminal blocks.

Fluorescent fixtures: fixtures shall be as specified on Drawings.

Lampholders generally shall be heavy duty molded white plastic with non-corroding spring contacts.

Lampholders for industrial fittings shall be spring loaded turret type.

Single or two lamp ballasts shall be used in any one fixture. Two lamp ballasts shall be lead-lag, series type. All equipment shall be enclosed in sheet steel casing with corrosion resistant finish.

Each ballast shall have a one-time external fuse and fuse holder rated in accordance with manufacturer's instructions.

Ballast shall be manufactured for the specific lamp it controls and for operation from power supply with voltage and frequency equal to nominal voltage and frequency of distribution network.

Electrical fittings – generally: supply and install electrical fittings including switches, sockets, lighting control equipment, together with matching outlet boxes and plates and connect to power supply and distribution system as shown on the Drawings and as required.

Drawings generally show approximate locations of outlets. Refer any condition that would place an outlet in an unsuitable location to the Engineer for a decision.

Where mounting heights or locations of outlets are not shown or specified, locate outlets as best suited for equipment connected there to or as directed by the Engineer.

Mount switches with long dimension vertical and operating handle up when in the off position.

Provide additional outlets to those shown on the Drawings as required by equipment manufacturer for control or other wiring. Fittings shall be weatherproof.

Exposed surface mounted boxes shall be galvanized cast iron with threaded hubs.

Switches shall be quick-make, quick-break type with silver alloy contacts in an arc resisting molded base, tumbler, rocker or button operated, rated 20 and 30 A, 240 V and 415 V AC, to interrupt inductive or resistive loads up to full rated capacity, arranged for side and back connection, with corresponding plates with screw terminals accepting at least two parallel branch circuit wires.

Switches shall be weatherproof.

2702.10 MEASUREMENT AND PAYMENT

2702.10.1 Method of Measurement and Basis of Payment

Equipment together with associated ancillaries are given separately and measured by the number of each type furnished, installed, tested and accepted. Equipment together with associated ancillaries are deemed to include:

- Factory assembled components and controls.
- Loose equipment supplied by the manufacturer.
- Electrical connection and wiring.
- Supports and fixation including supporting steel work or concrete work.
- Valves, strainers, flexible connections, controls, instruments and fittings as shown on the Drawings.
- Loose keys, tools and spare parts as specified.

Monorail system shall be measured as an Item, complete, installed, tested, and accepted.

Ventilation and Air conditioning system shall be measured as an Item, complete, installed, tested, and accepted.

Fire Fighting system shall be measured as an Item, complete, installed, tested, and accepted.

Electrical work in connection with pumping stations including but not limited to lighting fixtures, switches, socket outlets, etc. is given separately and measured as an item furnished, installed, tested and accepted and is deemed to include also all electrical work and wiring shown on the Drawings, described in the Specification or reasonably implied as necessary for the proper execution of the work.

The diesel generator set complete with all control, monitoring and automatic starting equipment, batteries and charger, fuel storage tank, fuel daily tank, pumps and piping, exhaust system, cooling system, automatic mains failure transfer switch, inter plant cabling and wiring, earthing system, spare parts and all other fittings and fixings to form a complete installation shall be measured as the number furnished, installed and put into operation after testing and accepted as meeting the specification in all respects.

The amount of completed and accepted work measured as provided for above, shall be paid for at the unit rates for the Pay items inserted in the Bills of Quantities, which rates shall be full compensation for furnishing all materials, for all labour, equipment tools, supplies and all other items necessary for the proper completion of the Works as specified and for testing, installation, and putting into operation.

2702.08.2 Items in the Bill of Quantities

PAY ITEM	DESCRIPTION	UNIT OF MEASUREMENT
2702.1	Submersible Drainage Pumps	nr
2702.2	Horizontal Pumps (type)	nr
2702.3	High Pressure Booster Pumping Set Employing Membrane Tank	nr
2702.4	High Pressure Booster Pumping Set Employing Variable Speed Pumps	nr
2702.5	Duplex Sump Pumps	nr
2702.6	Bladder Type Surge Tanks	nr
2702.7	Monorail System	item
2702.8	Instrumentation and Controls	item
2702.9	Electrical works	item
2702.10	Diesel Generator Set, indoor type, 415/240V, 3phase, 50Hz, rating (kW)	item
2702.11	Ventilation and Air Conditioning System	item
2702.12	Fire Fighting System	item

2703 - CONSTRUCTION REQUIREMENTS

2703.01 PIPE LAYING AND JOINTING

General: examine materials carefully for damage. Test for soundness in accordance with manufacturer's instructions before laying the pipe.

The Contractor shall examine materials to insure coating or lining and outer coating or sheathing is undamaged. If damaged, make good or dispose of and replace, as directed.

The Contractor shall remove dirt and foreign matter from pipe before lowering.

The Contractor shall clear construction debris from inside of pipe before making joint.

When pipe lying is not in progress, the Contractor shall close open ends of pipes with properly fitted temporary wooden plugs or standard caps as directed

Jointing: manufacturer’s instructions shall be followed regarding cleanliness of joint surfaces, lubricant used, correct location of components, provision of correct gaps for flexible joints etc.

Flexible joints shall not be deflected beyond maximum permissible angles given by manufacturer and/or relevant standard.

For patent detachable and flexible joints, the Contractor shall comply strictly with special instructions issued by manufacturers of proprietary joints when laying and jointing.

The Contractor shall joint differing pipe and fitting material with adaptors as recommended by pipe manufacturer.

2703.02 VALVES INSTALLATION

General: prior to installation, inspection for cleanliness of bores, seating surfaces etc. and for handling damage, cracks, missing parts and tightness of pressure-containing bolting shall be performed.

The Contractor shall ensure that valves are in the closed position before installation.

Valves must be operated through one complete opening and closing cycle in the position in which they shall be installed to ensure proper functioning.

Installations: joint valves to pipe must be set in the manner specified for laying and jointing pipe and/or to manufacturer's instructions.

Valves shall be provided with concrete pads as shown on the Drawings so that pipes do not support weight of valve.

Valves without concrete pads shall be placed on firm footings to prevent settling and excessive strain on connection to pipe.

Valves shall not be used to bring misaligned pipe into alignment during installation.

All pressure-containing bolting (bonnet, seal plate and end connections) must be inspected for adequate tightness after installation but prior to field testing.

2703.03 PUMPS INSTALLATION

Installation: realign pump and motor in the field after grouting in base and connecting piping.

Support piping independently of pump nozzles.

Drains for packing glands and base shall be piped to nearest floor drain or sump.

Before operation, the Contractor shall ensure pump is properly lubricated, rotating element rotates freely by hand, casing is vented and full of water, direction of rotation is correct, strainer is clean and suction and discharge valves are open.

2703.04 MEASUREMENT AND PAYMENT

2703.04.1 Method of Measurement and Basis of Payment

Related works and requirements of the General Requirements and Builder's Work in connection with Pumping Stations including all civil work shown on the Drawings, described in the Specification or reasonably to be implied as necessary for the proper execution of the work shall be considered as subsidiary Works, which shall not to be measured for direct payment, the cost of which will be deemed to be included in the Contract prices for relevant Pay Items.